SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MAY 1901.

GENERAL PHYSICS.

742. *Vortex Rings.* **G. Vicentini** and **G. Pacher.** (Rivista Sci.-Industriale, 33. pp. 17–25, Feb. 15, 1901. Atti del R. Istituto Veneto di Scienze Lettere e Arti.)—This paper is a description of experiments made on the vortex rings shot from the Stiger hail-preventing cannons. The Stiger cannon is a mortar with a sheet-iron funnel, the mouth of which is partially closed by a diaphragm with circular aperture. The air in this funnel forms the vortex-ring projectile. The authors' experiments are made with miniature cannons and are adapted to the lecture-room ; he examines the vortex-rings by their effects on targets of wire gauze, covered with a solution of soap and glycerine. A vortex-ring, striking such a target removes the liquid film from an annular portion, and also from the central area, leaving a narrow ring of liquid separating the two portions. The effect of funnels of different sizes and shapes is examined by means of these targets. Experiments are described with a Tait smoke-ring box, using as target a soap film on a wire ring. The nature of the vortex-ring projectiles is examined also by their action on flames, and by a Toepler manometer. G. H. B.

743. *Density of Liquid Chlorine.* **A. Lange.** (Chem. News, 83. pp. 134–136, March 22, 1901. From the Zeitschr. Angew. Chem. July, 1900.)—Results are given of measurements of the density of liquid chlorine at various temperatures and pressures, the method employed being that previously used by the author in the cases of sulphur dioxide and ammonia. The numbers obtained agree very well with those of Knietsch. The coefficient of compressibility of liquid chlorine has the values, 0·000225 at 35·4°, 0·000366 at 64·9°, and 0·000673 at 91·4°. T. H. P.

744. *Optical Methods for Studying Elasticity.* **A. Cornu.** (Archives Néerlandaises, 5. pp. 322–338, 1900.)—In studying the elasticity of some substances, *e.g.*, crystals which can only be obtained in small specimens, special methods are required. The two methods referred to are :—

I. *Using Newton's Rings.*—If the surface of the body be planed and polished, and then a convex lens placed over it, we can obtain the rings by monochromatic light. If now the body be strained by (1) a force applied perpendicular to the plane surface, or by (2) a torsion, in either case the rings will change in size and shape. Then proceed to measure the rings by a micrometer, and apply Euler's theorem of the relation of the deformation of the surface to the variation of the curvatures.

II. If the surface be strained as above described, then a lens, having one of its three supports on the surface, will be rotated by a small amount; in consequence an image, which before the strain was truly sharp, now becomes *astigmatic*, and we have to observe not an image but two focal lines.

The theory of lenses will enable the movement to be found from the observed positions of the focal lines.

Details of the manipulation, and a comparison of the two methods showing that they are equally sensitive, are given. P. E. S.

745. *Relation between Brittleness and Elastic Limits for Tension and Pressure.* **C. Frémont.** (Comptes Rendus, 132. pp. 202–203, Jan. 28, 1901.)—The author arrives, from experimental data, at the important conclusion that steel is brittle (*i.e.*, breaks suddenly with small expenditure of work) or tough (*i.e.*, breaks gradually with an expenditure of work proportional to that required for rupture by tension), according as the ratio of the elastic limit for tension to the elastic limit for compression is less or greater than unity.

J. E.-M.

746. *Effect of Tension on Permanent Torsion of a Wire.* **J. R. Benton.** (Phys. Rev. 12. pp. 53–54, Jan., 1901.)—Himstedt has investigated the torsion produced in a wire hanging free with weights fastened to its lower end, when these weights are changed. The author shows that similar changes are caused in the permanent torsion of a wire by increasing its tension when it is clamped fast at top and bottom. A table of results is given. W. C. H.

747. *Poisson's Ratio Determined by Means of an Interference Apparatus.* **J. R. Benton.** (Phys. Rev. 12. pp. 36–42, Jan., 1901.)—After relating the different methods adopted by different investigators to determine Poisson's ratio, the author, desiring to measure the actual contraction in wires subjected to longitudinal stress, describes a method of, and apparatus for, measuring the contraction, naturally very small, by means of interference bands. The values of Poisson's ratio thus found for a number of wires are given in a table. The following are some of the values given :—

Steel	0·2755
Iron	0·288
Copper	0·341

W. C. H.

748. *Experimental Investigation into the Flow of Marble.* **F. D. Adams** and **J. T. Nicolson.** (Roy. Soc., Phil. Trans. 195. pp. 363–401, Jan. 5, 1901; Roy. Soc., Proc. 67. pp. 228–234, Nov. 14, 1900 (Abstract).)—Cylinders of marble, 1·5 inch high, 1 or 0·8 inch in diameter, were passed into wrought-iron tubes, built up like pieces of ordnance of strips of Low Moor iron, and fixed in the respective tube by heating the latter. Pressures up to 18,000 atmospheres were applied by vertical steel pistons from above and below. When the pressure reached 18,000 lbs. per square inch, the tubes began to bulge out, and finally burst. The experiments lasted from 10 minutes to 67 and 124 days, and were conducted in the cold and at temperatures of 300 and

400° C., in the dry and under admission of steam; the moisture made no appreciable difference. The observed permanent deformations in the marble confirm Heim's view on deformation without fracture as a factor in the mechanism of mountain formation in the deeper portions of the earth's crust. At ordinary temperature a cataclastic structure and twinning and gliding movements in the individual crystals result; at 300° C. and above, the cataclastic structure is no longer observed, the movements consisting entirely of changes in the shape of the component calcite crystals by twinning and gliding. There is thus a flow of marble identical with the flow of metals. Whether the pressure is applied rapidly or slowly, does not seem to affect the final appearance; but rapid deformation weakens the marble, reducing its resistance to crushing from 12,000 lbs. to 2,775 lbs., whilst the slowly deformed marble retains its strength. The structures of the artificially deformed marbles were found in sixteen out of forty-two specimens of natural marbles and limestones, especially selected from contorted districts; in the other cases the resemblances were doubtful or absent. H. B.

749. *Use of Bicycle Wheel in Illustrating the Principles of the Gyroscope.* **C. T. Knipp.** (Phys. Rev. 12. pp. 43–46, Jan., 1901.)—The author shows how to construct a very simple, but effective, form of gyroscope from an ordinary bicycle wheel. This works equally well as a gyroscopic pendulum, as a balanced gyroscope, and as a top. In the ordinary form of gyroscope the true oscillatory motion of the axis is not shown except for very low speeds, and even then the oscillations are quickly damped by the friction of the supports. In the bicycle wheel gyroscope the friction at the hub, on account of the ball bearings, is very much less in proportion to the masses in motion; and, as the large diameter of the wheel and consequently small angular velocity make the precessional and oscillatory motions slow, these can be followed more easily. W. C. H.

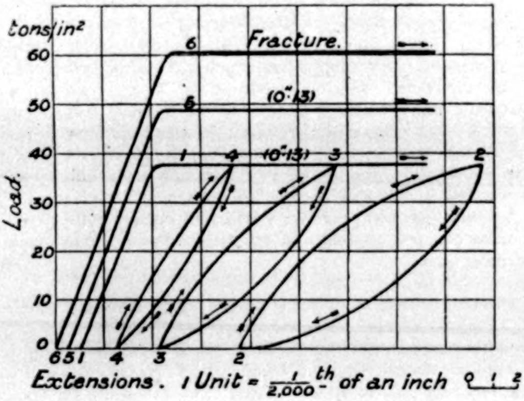
750. *Precision in Determinations of Length.* **J. R. Benoit.** (International Physical Congress at Paris, Report, 1. pp. 30–77, 1900.)—A *résumé* of the practice and progress in different countries as to the standard and measurement of length. France, England, Russia, and Germany are dealt with, and the extension of the metric system noted. The best form for standards of length is discussed and the tests they should bear are described. As to the accuracy attainable in comparing thirty standard metre bars, the probable error of a single comparison is calculated to be $\pm 0{\cdot}12\ \mu$, and the probable error of the value of any one of the bars is thus $\pm 0{\cdot}04\ \mu$. The permanence of the standards and their variations with temperature are also treated.

E. H. B.

751. *Tempering of Iron Hardened by Overstrain.* **J. Muir.** (Roy. Soc., Proc. 67. pp. 461–466, Jan. 19, 1901.)—This paper describes experiments carried out on rods of iron and steel about $\frac{3}{8}$ths of an inch in diameter and 11 inches in length, the elastic condition of the material being in all cases determined by means of tension tests in which the hardness of the material was indicated by the "yield-point."

A $\frac{1}{2}$-inch rod of semi-mild steel, tested in the condition received from the makers, gave a well-defined yield-point at a stress of 38 tons per square inch, the material yielding at that stress by 0·18 inch on a 4-inch length. Curve No. 1 of the figure illustrates this. Curve No. 2 illustrates the semi-plastic state of the material produced by just passing this primary yield-point. The specimen was then laid aside for 1¾ days and once more tested. Curve No. 3 shows the progress made during this interval of rest towards recovery of elasticity. Curve No. 4 shows the condition of the overstrained material after it had been resting for two weeks. To insure perfect recovery of elasticity, the specimen was heated to 200° C. After cooling curve No. 5 was obtained with a yield-point at 49 tons per square inch, an increase of 11 tons. The material, after this second overstrain, was once more in a semi-plastic state, and curves similar to No. 2 could have been obtained, but with the loading continued up to 49 tons per square inch. Had the loading been continued beyond this when the material was in a semi-plastic state, large yielding would have taken place and fracture would have occurred at probably a very slightly increased load. On again annealing at 200° C. curve No. 6 was obtained, showing that the specimen bore the stress of 60 tons per square inch (another increase of 11 tons), but that fracture took place at 60½ tons.

(Steel as supplied.)



Another diagram is given in the paper showing that annealing altered in an interesting manner the elastic properties of the steel, whose virgin properties were illustrated in the figure given.

This same steel, after being annealed at 750° C. before being tested, gave its primary yield-point at 29 tons per square inch, and finally fractured at 59½ tons per square inch, after its yield-point had been four times raised by a step of about 7½ tons per square inch, due to annealing at 300° C. each time.

It was found that the steel in the condition as supplied could be tempered, or partially annealed, by heating to various temperatures below 750° C., the ordinary annealing temperature, and the lower the temperature the higher the yield-point. E. C. R.

752. *Viscosities of Mixtures of Liquids and of Solutions.* **C. H. Lees.** (Phil. Mag. 1. pp. 128–147, Jan., 1901. Paper read before the Physical Society of London.)—In the endeavour to discover the law of connection of the viscosity of a mixture with the relative amounts and viscosities of its constituents, many investigations have been made of the viscosities of mixtures

and of solutions, and the results have led to several empirical formulæ being proposed, which represent with more or less accuracy the observations made. The author, after considering the necessary and sufficient conditions for the solution of any "plane" problem on the motion of viscous fluids, proceeds to discuss a few stable arrangements of the fluids for which the solutions can be readily obtained, and derives the following three formulæ :—

$$\frac{1}{\eta} = \frac{v_1}{\eta_1} + \frac{v_2}{\eta_2} + \frac{v_3}{\eta_3} + \ldots\ldots \quad (1)$$

$$\eta = v_1\eta_1 + v_2\eta_2 + v_3\eta_3 + \ldots\ldots \quad (2)$$

$$\log \eta = v_1 \log \eta_1 + v_2 \log \eta_2 + v_3 \log \eta_3 + \ldots\ldots \quad (3)$$

where η, η_1, η_2, &c., denote respectively the viscosities of the mixture and of the separate components present therein, and v_1, v_2, &c., denote the number of c.c. of each component present in 1 c.c. of the mixture. Comparison of values calculated by these formulæ with those observed by various experimenters for a large number of mixtures and solutions, shows that no one of the three represents the viscosity of a mixture with sufficient closeness. The author therefore suggests the empirical formula,

$$\left(\frac{1}{\eta}\right)^m = v_1\left(\frac{1}{\eta_1}\right)^m + v_2\left(\frac{1}{\eta_2}\right)^m + \ldots\ldots \quad (4)$$

where m is a constant to be determined for each mixture. This formula, with a suitable value for m gives a satisfactory representation, and when applied to express the variation of the viscosity of a single liquid with temperature, by regarding a liquid at temperature t as produced by a mixture of suitable proportions of the liquid at temperatures 0 and t_1 respectively, it leads to the formula proposed by Slotte for the variation of the viscosity of a liquid with temperature. W. C. H.

753. *Apparatus for the Circulation of Liquids at Constant Temperature.* **I. H. Derby.** (Journ. Phys. Chem. 5. pp. 17–20, Jan., 1901.)—Two devices are described for the maintenance of a stream of water between a jacket kept at a constant temperature and a bath. The water is made to pass from the bath through a tube to the jacket from which it passes back to the bath by means of another tube dipping beneath the surface of the liquid. In the first apparatus the circulation is effected by a screw propeller working at high speed in the exit tube of the bath ; the water in the latter is not well mixed in this way, so that a stirrer is necessary. In the second method, the entry tube of the bath is surrounded by another tube fitted near the top with a driving wheel, and blown out at the bottom into a bulb, the walls of which contain two holes opposite to one another. When this outer tube is rotated, the water coming into the bath by the entry tube is thrown outwards in the form of a fine spray, and well mixed with the other water. In this case no stirrer is required, and a constant circulation is kept up. Illustrations are given of the apparatus, which give good results. T. H. P.

754. *Muscular Energy.* **A. Chauveau.** (Comptes Rendus, 132. pp. 194–201, Jan. 28, 1901.)—The subject, weighing 50 kg., was made to work by ascending or descending a Hirn wheel, carrying loads of 10 or 20 kg., at different speeds. The conditions of the experiments were not varied in other respects, and very little altogether. Each experiment lasted about ten minutes, and the exhaled air was collected during the last six minutes; from the analysis of this air the oxygen consumption was deduced. The ratio of work done in kgms. to the energy expenditure (the equivalent of the calories) forms the basis of the conclusions. For varying loads the energy expenditure is proportional to the load; but work at a quick rate requires comparatively less energy than work at a slower rate. The above-mentioned ratio varied a good deal; the average is 0·2 for ascending, and 0·389 for descending. The author considers that the energy expenditure comprises three terms:—The internal work which balances the load in the state of static contraction; the increase or decrease in this internal work on raising or lowering the load, when the static contraction passes into a positive or negative dynamic contraction; and the positive or negative external work corresponding to the creation or extinction of potential or actual energy. H. B.

755. *Progressive Long Waves in Shallow Water.* **R. F. Gwyther.** (Phil. Mag. 1. pp. 106-110, Jan., 1901.)—In continuation of previous papers [see Abstract No. 2143 (1900)] the author seeks the whole range of periodic long waves in water of uniform depth, limited by the condition that the uniform velocity applied throughout the fluid may make the motion steady. The different possible solutions are found to depend upon the roots of a quadratic, solutions suitable for periodic waves corresponding to intervals between the roots, and presenting themselves in the same form in terms of the elliptic function of the second kind. The resulting waves are waves of elevation, each value of the modulus corresponding to two waves travelling with different rates and accompanied by a motion of drift. In the extreme case there are obtained Scott-Russell's Solitary Wave and a comparatively slow solitary wave of elevation, accompanied by a perceptible drift. The need for this drift and the existence of long waves not accounted for by the method seem to point to the probability of a more complex motion than a uniform drift being necessary for the exhibition of the phenomena, and to throw doubts on the advantage of studying this wave by a reduction of the motion to steady motion. A condition is found for the identity of the waves with the type of Cnoidal Wave given by Korteweg and de Vries. W. E. T.

756. *Lorentz's Theory and the Principle of Reaction.* **H. Poincaré.** (Archives Néerlandaises, 5. pp. 252-278, 1900.)—The author explains in his first section how the law of equality of action and reaction is not satisfied in Lorentz's theory, if that law is to be applied to ordinary matter only. He gives an analytical expression for any component, X, of the ponderomotive force acting on the Lorentz electrons within a certain space. This expression contains two terms corresponding respectively to Maxwell's magnetic pressure and electrostatic pressure on the bounding surface of the space. It contains also a third term $\frac{d}{dt}\int d\tau\,(\beta h - \gamma g)$ in the usual notation. Now if M be the mass, V_x, V_y, V_z the component velocities, of any particle of matter within the space considered, the equality of action and reaction requires that $\Sigma MV_x =$ constant. What we really obtain is, since Maxwell's pressures disappear for an infinitely distant surface, $\Sigma MV_x + \int d\tau\,(\gamma g - \beta h) =$ constant. It is noted that the vector whose components are $\gamma g - \beta h$, &c., is Poynting's radiation vector.

Poincaré then supposes the electromagnetic energy, of which Poynting's vector denotes the flow, to be an imaginary fluid possessing inertia, of density K_0J, where $\frac{1}{\sqrt{K_0}}$ is the velocity of light, so that K_0JU_x represents the x component of Poynting's vector. He makes a special hypothesis to get over the difficulty that the imaginary fluid is not indestructible, but its quantity is subject to increase or diminution by interchange with other forms of energy.

Assuming the imaginary fluid to possess inertia, we should expect that the apparatus *e.g.*, a Hertz oscillator, which produces electromagnetic energy, and sends it on its way through space, should recoil like a fired cannon, though, as shown, such recoil would not be measurable by our methods. The new term introduced, namely, $\frac{d}{dt}\int d\tau\,(\beta h - \gamma g)$, disappears as stationary motion is established. The recoil, therefore, depends ultimately only on Maxwell's pressures. And since all theories involve Maxwell's pressures, they all involve the same recoil.

In his second section Poincaré considers the question why Lorentz's theory, which does not obey the law of action and reaction, and Hertz's theory, which does obey it, lead to the same recoil. To answer this he discusses the case of a material dielectric, and the passage of a wave through it on Lorentz's principles. He explains that Lorentz's theory stands in the same relation to that of Hertz, as Mossotti's theory to that of Maxwell. We pass from the one to the other by assuming the polarised particles of the original one to become infinitely small in the derived theory. If $\frac{1}{\sqrt{K_0}}$ denote the velocity of light in Lorentz's original theory, we must in a modified theory use $\frac{1}{n_0\sqrt{K_0}}$, n_0 being the index of refraction of so-called vacuum in relation to an ideal unpolarisable medium. The author then shows that when the apparatus projects energy into space, part of the recoil is taken up by the dielectric, and part by the apparatus, the proportion of the whole taken by the dielectric being $\frac{n^2-1}{n^2+1}$ where n is the index of refraction of the dielectric. In the modified theory we must use $\frac{n^2n_0^2-1}{n^2n_0^2+1}$ instead of $\frac{n^2-1}{n^2+1}$. For Hertz's theory n_0 is infinite, and therefore *the whole recoil* is taken by the dielectric. This is the reason why Hertz's theory obeys the law of action and reaction.

In his third section the author discusses the principle of action and reaction, and our reason for assuming it as axiomatic, from a general point of view. It is intimately connected with the theory of relative motion. To show this he considers the case of two observers at a distance x from each other, who set their watches by signalling through the intervening distance without being aware that they have a common velocity v of translation through space. If t' be the time so observed, t the real time, and V the velocity of light, we have, he shows, $t' = t - \frac{vx}{V^2}$. The apparent energy is propagated in the relative motion according to the same laws as the real energy in the real motion. But the apparent energy is not precisely equal to the real energy.

In the relative motion the bodies which emit energy are subject to a certain *complementary force* which is obtained as follows:—

Suppose, for instance, a Hertz oscillator placed at the focus of a parabolic mirror, whose axis is taken for that of x. The system is supposed to have a small velocity v' of translation in that direction. The apparatus experiences a recoil with velocity v' in the opposite direction, and v' is supposed greater than v, so that v^2 is neglected, but not vv'. The force of the recoil is equivalent to the increase of momentum of the imaginary Poynting fluid, namely, $K_0JV = J/V$. The energy of the recoil is therefore $-\frac{Jv'}{V}$. If D be the energy spent by the oscillator, the equation of energy of the real motion is—

$$J - D - v'J/V = 0.$$

For the apparent motion, taking into account the translation velocity v, we substitute $J\left(1-\frac{v}{V}\right)$ for J, and $v'-v$ for v'. The resulting apparent equation of energy is $J\left(1-\frac{v}{V}\right) - D + J\left(\frac{v'}{V}+\frac{v}{V}+\frac{vv'}{V^2}\right) - \frac{Jvv'}{V^2} = 0$. The last term is necessary to make the apparent equation of energy agree with the real equation. It implies a force on the apparatus $-\frac{Jv}{V^2}$, which does work $-\frac{Jvv'}{V^2}$ on the apparatus moving with the recoil velocity v'. This force the author calls *the complementary force.*

This is the explanation of the fact that in Lorentz's theory the principle of action and reaction cannot apply to matter alone, and the same is true of the principle of relative motion. S. H. B.

757. *Surface Tension.* **H. Halshof.** (Ann. d. Physik, 4. 1. pp. 165–186, Jan., 1901.)—The object of this paper is to show that the assumptions on which is based the equation of condition for a substance whose density changes continuously in a capillary layer lead to the conclusion that surface tension exists. The assumption of continuity of density requires that all densities between that of the liquid and that of its saturated vapour should be represented. It does not, however, follow that all states represented by an isotherm must be found in the capillary layer. For the states represented by different points of the isotherm presuppose a certain homogeneity of the substance. Those functions only which depend on the molecular velocity and the density will have the same value in the transition layer as in a homogeneous distribution. This is the case with the entropy and the thermal pressure δ. Supposing a thin column of fluid of base *ab* perpendicular to the fluid surface and in the external space, and supposing no forces to act except the molecular attraction, the molecular pressure is defined to be the force with which the substance on one side of the plane on which *ab* lies attracts the column of fluid in a direction perpendicular to the surface. If the distribution is not homogeneous the molecular force will have different values in different directions. The writer assumes that the density has at every instant the same value at every point of any horizontal layer, but is a function of the vertical distance from a given horizontal plane, and on this hypothesis he calculates the molecular pressure, first in the vertical and then in a horizontal direction. The vertical component is shown to have a different value from the components in the surface. And this fact it is, according to the present paper, which gives rise to surface tension. The surface tends to contract itself with a force depending on the difference between the components of the molecular attraction. The relations of the phenomenon to changes of temperature and density are investigated.

S. H. B.

758. *Rigidity of Liquids.* **T. Schwedoff.** (International Physical Congress at Paris, Report, 1. pp. 478–486, 1900.)—The author points out that the distinction between solids and liquids is not in all respects abrupt, but that solids show some of the properties commonly ascribed to liquids, and *vice versâ.* He describes an experiment of Maxwell's, afterwards repeated by Kundt and Metz, in which a liquid was contained in the space between two coaxial cylindrical vessels, the inner vessel being set in rotation, and it was found that the liquid, affected by the rotation of the inner cylinder, had the property of polarising light. M. Schwedoff then describes an experiment of his own, in which a cylindrical glass vessel filled with granules was suspended by a steel wire in the interior of another vessel, the space between the vessels containing the liquid to be observed. The wire being then thrown into a state of torsion, the suspended vessel acquires rotation and communicates it to the liquid. The theory of this experiment is represented by the formula—

$$E = a\frac{\delta}{w}$$

Where δ and w are the angles of torsion of the wire and liquid respectively at the instant of equilibrium, a is a constant, and E the modulus of rigidity required.

The writer also discusses the relation between deformation in liquids and internal friction, first raised by Maxwell, and arrives at the following results:—(1) The viscosity of a liquid depends on its modulus of rigidity, on the limit of its spring, on the speed of relaxation, and on the speed of deformation. (2) The viscosity of a liquid is not constant, but may vary with the speed of deformation. (3) The change in viscosity is more sensible as the limit of elasticity increases. (4) When the rigidity cannot be measured directly, the liquid may nevertheless be very viscous, if the speed of relaxation be small. (5) On the other hand, a liquid may present great fluidity and yet have a measurable modulus of rigidity, that is if the speed of relaxation be very great. S. H. B.

759. *Action at a Distance in Hydrodynamics.* **V. Bjerknes.** (International Physical Congress at Paris, Report, 1. pp. 251–276, 1900.)—The author supposes an infinite incompressible fluid. If in that fluid there be a very small sphere which, without changing the position of its centre, increases or diminishes its radius, it causes a radial movement in the fluid, the velocity of which varies inversely as the square of the distance from the sphere, and may be derived from the potential $\phi = -\frac{E'}{4\pi r}$, where E′ is the velocity of expansion of the sphere, r the distance from its centre. If there be a number of such spheres in the fluid, we have, by a simple enumeration, $\phi = -\Sigma\frac{E'}{4\pi r}$. If the oscillation is for each sphere the same periodic function of the time, the spheres are said to have *synchronic pulsations,* and in this case the field is, as regards its mean state, constant.

From a pulsating sphere to a sphere of constant volume moving with finite velocity a', b', c', in direction s, the transition is effected by known methods, and it is found that in this case $\phi = -S'\frac{d}{ds}\frac{1}{4\pi r}$, where S′ is the vector whose components are $F' = \frac{3}{2}a'E$, $G' = \frac{3}{2}b'E$, $H' = \frac{3}{2}c'E$. On these data the writer discusses the mathematics of a sphere moving in the fluid with velocity a', b', c', under the influence of a stream α', β', γ', caused by the pulsation or motion of other spheres. He finds that the force X, acting at any instant on the sphere, consists of two parts, namely $X = X_i + X_e$. Here $X_i = -g\frac{d}{dt}\left\{E\left(\frac{1}{2}a' - \frac{3}{2}a\right)\right\}$, with corresponding components Y_i, Z_i, and g is the density of the incompressible fluid. This force is called the *force of induction.* The other part of X, or X_e, is given by—

$$X_e = -g\alpha' E' - g\left(\frac{d\alpha'}{dx}F' + \frac{d\alpha'}{dy}g' + \frac{d\alpha'}{dz}H'\right),$$

with corresponding equations for Y_e and Z_e. This is called the *energy force.* The effects of the force of induction are found to correspond with well-known properties of the electric and magnetic forces in an electric field.

The energy force is again divided into two parts, the permanent and the temporary force, of which the former is independent of the stream, the latter depends upon it. The permanent force has its origin in pulsations or oscillations of a sphere independent of the stream, the latter on oscillations caused by the stream, and depends, therefore, ultimately on the pulsations or oscillations of other spheres. It is found that the permanent force diminishes according to the second, third, and fourth inverse powers of r, whereas the temporary force depends on the fifth and higher powers. The general conclusions at which the author arrives are as follows: Imagine a world consisting of spheres immersed in an incompressible fluid, and pulsating or oscillating, and that groups of such spheres form substances. The inhabitants of such a world, unaware of the existence of the fluid, would conclude from observations of the spheres that they were acted upon by forces at a distance, according to the Newtonian law, and subject to the conservation of energy. But, in fact, the only actions are contact actions due to the (to these inhabitants) unknown fluid. The writer concludes with a discussion of the analogy between his own hydrodynamic system and the electric or magnetic system, notably the theory of Hertz. He claims that his theory, as shown in this paper is, in some points, an advance on Hertz's theory, because he gives the mechanism of the medium whereby contact forces give rise to (apparently) forces acting at a distance, whereas Hertz was unable, from the nature of his work, to specify the mechanism. He refers also to O. Heavisides' system of "rational" units, according to which we take for the unit of force between two attracting spheres m and m', not $\frac{mm'}{r^2}$, but $\frac{mm'}{4\pi r^2}$. And this system he considers must sooner or later be adopted.

S. H. B.

760. *General Principles for the Dynamics of Ether.* **J. Farkas.** (Archives Néerlandaises, 5. pp. 56–75, 1900.)—The writer considers that the scientific treatment of dynamics is as yet deficient in generality. An extension is required both for ordinary mechanics and for ether. He proposes to use the principle of virtual displacements in the form given by Fourier and Gauss, that is, the principle of inequations, which has advantages over that of equations. Generally the principle of virtual displacements, whether in the form of equations or inequations, is applicable only when the surrounding medium has no resistance and there is no friction. In his first chapter the author extends the principle so as to include the case where these exist. In his second chapter he generalises the analytical expression for constraint. This is generally assumed to be expressible by homogeneous linear equations or inequations, among the displacements. But there are cases, he maintains, in which such relations are insufficient. In the above first and second chapters only discrete masses are considered. In the third the treatment is extended to matter continuous in space. This also includes a generalisation of the equation of continuity. In the fourth chapter the hypothesis is dealt with that in an independent system of masses, for certain positions of the axes of co-ordinates, no free forces appear. And this hypothesis is applied to the relations between the ether and matter in any space regarded as parts of the same dynamical system. In the case of certain bodies it is necessary to assume that different portions of ether in the same space are subject to different constraints, and that these may be converted one into another. Experience teaches us that surface friction between ether and matter can be only very slight in all motions which we can observe. But this is not inconsistent, says the author, with the hypothesis that in the interior there may be considerable friction. Nor is this hypothesis inconsistent with Lorentz's assumption that ether has nothing to do with—*i.e.*, takes no part in—the visible motions of bodies. S. H. B.

761. *Capillary Phenomena.* **G. van der Mensbrugghe.** (International Physical Congress at Paris, Report, 1. pp. 487–511, 1900.)—The writer refers to experimental proofs of the great elasticity of liquids, firstly under compression, secondly under traction. From these proofs he draws the conclusion that liquids cannot be regarded practically as incompressible, and that a liquid cannot have a uniform density at all points in its substance; for that if it had, equilibrium would be impossible. The writer does not, however, give a definition of density as a function of the position of the point considered varying from one point to another within the same liquid.

From these considerations he draws the following conclusions:—Firstly, that superficial tangential tensions must exist in the outer layer of the liquid; secondly, that normal tension must exist, giving rise to evaporation: and these conclusions are, he says, confirmed by the experience of engineers.

Next he discusses the relations that prevail between these functions, at the surface of contact (1) of a solid and a liquid, (2) of two liquids, and the theory of the spreading of one liquid over the surface of another. The law found is, that in order that one liquid may spread over the surface of another, it is sufficient and necessary that the mutual action should be greater than the tension of the two surfaces. Finally is discussed the equilibrium of a thin column of liquid within another liquid. S. H. B.

762. *Laplace's Capillarity Constant.* **G. Bakker.** (Journ. de Physique, 10. pp. 135–139, Feb., 1901.)—If $f(r)$ denote the force acting between two molecules at distance r, and if—

$$\phi(r) = \int_r^\infty f(r)dr, \quad \psi(r) = -\int_r^\infty r^2(\phi r)dr,$$

the potential energy for volume v is—

$$W = 2\pi\psi\rho^2 v D,$$

ρ being the density, and D the diameter of a molecule. Referring to a former paper (Journ. Phys. 3 serie t VII. p. 511, 1898) the writer finds for the virial of the molecular forces, $\mathfrak{V} = \frac{3}{2} v \frac{dw}{dv}$, whence $2\mathfrak{V} + 3W = 0$, or if A is the work done in removing all the molecules out of one another's field, $3A - 2\mathfrak{V} = 0$. In the present paper he proves that the expression $(3A - 2\mathfrak{V})$, which is zero at any point in the interior of the liquid, is in fact the surface tension in the case of the capillary layer. He adopts the form of force for distance r arrived at in the paper referred to in Abstract No. 2139 (1900), namely $-f\frac{\epsilon^{-qr}}{r}$. And then, following van der Waals, he gives for the potential at a point in the capillary layer—

$$V = -2a\rho - \frac{c_2}{1\,2}\frac{d^2\rho}{dh^2} - \frac{c_4}{1\,2\,3\,4}\frac{d^4\rho}{dh^4} \text{ \&c.},$$

in which—

$$c_n = \int_c^\infty u_n \psi(u)du,$$

and—

$$\psi(u) = 2\pi\int_n^\infty u\phi(u)du,$$

$\phi(u)$ being the force. Again, in the paper of July, 1900 [Abstract No. 2139 (1900)], he had obtained for the surface tension H, the expression—

$$H = \frac{1}{4\pi f}\int_1^2 \left(\frac{dV}{dh}\right)^2 dh,$$

V being van der Waals' potential above mentioned, dh an element of the normal to the two surfaces of the layer, and the indices 2 and 1 referring respectively to the saturated vapour and to the liquid. And the last expression is proved equal to $3A - 2\mathfrak{V}$. [See also Abstracts Nos. 2138 and 2139 (1900) and 509 (1901).] S. H. B.

763. *Numerical Relation between the Two Elasticity Constants of Isotropic Substances according to the Molecular Theory.* **W. Voigt.** (Ann. d. Physik, 4. 1. pp. 187–196, Jan., 1901.)—The old molecular theory gave results for isotropic media which could not be reconciled with experience. Voigt's investigations pointed to the assumption that intermolecular forces depend only on distance as the source of error, and the difficulty appeared to vanish in the case of crystalline bodies on assuming the force to depend for its direction on the symmetry relations of the crystal. The same method, applied to isotropic media, led only to the erroneous theory, so long as such media are regarded as molecularly isotropic; *i.e.*, so long as neighbouring molecules are orientated with respect to each other in all directions indifferently. For on that assumption, we have the equation—

$$-X_x = CX_x + C_1Y_y + C_1Z_z,$$
$$-Y_z = \tfrac{1}{2}(C - C_1)\,Y_z,$$

with the relation $C = C_1$, which is inconsistent with experience. The difficulty disappears if we assume the isotropic bodies to be made up of fragments of crystalline substance in all possible orientations—a state which Voigt defines as *quasi isotropy*. This solution being inapplicable to liquids, the object of the present paper is to show how the difficulty can be removed.

Voigt obtains the following formulæ [(7) in his notation]:—

$$u' = x_x x' + \tfrac{1}{2} x_y y' + \tfrac{1}{2} x_z z',$$
$$v' = \tfrac{1}{2} y_x x' + y_y y' + \tfrac{1}{2} y_z z',$$
$$w' = \tfrac{1}{2} z_x x' + \tfrac{1}{2} z_y y' + z_z z',$$

in which x', y', z' are the co-ordinates, u', v', w' the displacements of a molecule, relative to a type molecule. These are the fundamental equations of the "Nahewirkung" theory of elasticity. But these, he says, cannot be applied to the molecular theory except on the following assumption, namely, "that within the molecular sphere of action, molecules behave, when deformation takes place, like particles of a continuous medium capable as well of translations and rotations in mass as of uniform dilatation in three mutually perpendicular directions." Substances for which this assumption may be at once admitted are to be regarded as ideal liquids. On the other hand the formulæ (7) are to be regarded as characteristic of elastic solids. A third class of bodies to which (7) are inapplicable are to be regarded as possessing a certain degree of fluidity.

Voigt finally obtains a set of formulæ from which C/C_1, the ratio of the two constants, can be calculated, and may have any value between 1 and 3, according to the degree of rigidity. The result is compared with Thomson's "modulus of rigidity." S. H. B.

764. *Artificial Solar Eclipse.* **R. W. Wood.** (Science, 13. pp. 65–67, Jan. 11, 1901.)—The article gives particulars of the construction of an apparatus which may be useful for representing a total solar eclipse. An electric glow-lamp is suspended in a tank containing a slightly milky fluid (water and mastic varnish) and having an opaque disc in front to represent the dark moon. Bands of opaque paper pasted on the lamp produce the appearance of coronal streamers radiating from the moon's limb. The article is illustrated by a photograph of the appearance produced. C. P. B.

765. *Electromagnetic Foundation of Mechanics.* **W. Wien.** (Archives Néerlandaises, 5. pp. 96–107, 1900.)—While acknowledging the great services rendered by various workers on the relation between mechanics and electromagnetic phenomena, the author feels that the present state of theory leaves much to be desired. The view is then put forward that the most promising direction for theoretical work lies in the reversal of the usual methods, and the seeking of a possible electromagnetic theory of mechanics instead of a mechanical theory of electromagnetism.

The conception of the electric and magnetic polarisations of free ether, as expressed by Maxwell's differential equations, are then taken as fundamental, and written as follows:—

$$A\frac{\partial X}{\partial t} = \frac{\partial M}{\partial z} - \frac{\partial N}{\partial y}, \quad A\frac{\partial L}{\partial t} = \frac{\partial Z}{\partial y} - \frac{\partial Y}{\partial z}, \quad \text{.......................(1)}$$

and the two corresponding groups of equations, where X, Y, Z, are the components of the electric polarisation, L, M, N, those of the magnetic polarisation, A the reciprocal of the velocity of light, and x, y, and z the rectangular co-ordinates.

From these, by space differentiation, addition and time-integration, are derived—

$$\frac{\partial X}{\partial x} + \frac{\partial Y}{\partial y} + \frac{\partial Z}{\partial z} = -4\pi\sigma, \quad \frac{\partial L}{\partial x} + \frac{\partial M}{\partial y} + \frac{\partial N}{\partial z} = -4\pi m, \text{...........(2)}$$

σ and m being respectively the electric and magnetic quantities.

On multiplying the first column of equations (1) by X, Y, and Z, and the second by L, M, and N, adding the whole together, and integrating throughout a closed space whose surface element is dS and its normal n, the following is obtained :—

$$\frac{1}{8\pi}\frac{d}{dt}\iiint dx\,dy\,dz\,(X^2+Y^2+Z^2+L^2+M^2+N^2)$$

$$=\int dS\left\{(YN-ZM)\cos(nx)+(ZL-XN)\cos(ny)+(XM-YL)\cos(nz)\right\}\ \ldots(3)$$

If on the surface either X, Y, and Z, or L, M, and N vanish, we have—

$$\frac{1}{8\pi}\iiint dx\,dy\,dz\,(X^2+Y^2+Z^2+L^2+M^2+N^2)=\text{constant}\ \ldots\ldots(4)$$

The left side of (4), which is constant, when taken over a sufficiently large space is called the electromagnetic energy.

The assumption is now made that mechanical phenomena are of electromagnetic nature and may therefore be developed upon the foregoing basis.

It is further assumed that what is termed matter is made up of the positive and negative electric quantities or elements which we regard as the convergence points of the lines of force. The ether itself is regarded as at rest. Changes of position are ascribed only to the electric quantities. All forces are considered to be of the electromagnetic type and are traced to stresses in the ether.

At low velocities of the moving quantities electrostatic forces would act between them. Whether the molecular forces are explainable in this hypothesis must be left for the present. It is, however, clear that by different groupings of positive and negative quantities at different distances very complex effects could be obtained. By these assumptions it is believed possible to diminish the difficulty which has hitherto been felt respecting Michelson's interference experiment and the theory of the ether at rest. For H. A. Lorentz has shown that the length of a body in the direction of the earth's motion with velocity v is shortened in the ratio $\sqrt{1-A^2v^2}$, if the molecular forces can be replaced by electrostatic forces. Hence Michelson's result is explained, if we can apply this to the molecular motions. The theories of gravitation, inertia, apparent increase of mass in rapidly moving bodies (as in kathode rays), and the laws of motion are then dealt with on this electromagnetic basis. E. H. B.

REFERENCES.

766. *Sources of Error in the Cavendish Gravitational Balance.* **M. Brillouin.** (Comptes Rendus, 131. pp. 1293–1296, Dec. 31, 1900.)—The author gives values for the corrections which must be made in determining the constant of gravitation, by Cavendish's method, on account of the combined action of the ellipsoidal form of the earth and temperature-change of rigidity of the wire ; and discusses the corrections necessary to eliminate the effects of the gravitational potential of the building in which the experiment is made. J. E.-M.

767. *Atmospheric Electricity.* **A. G. M'Adie.** (Journal of Electricity, S.F. 10. pp. 47–48 ; Discussion, pp. 48–49, 1900. Paper read before the Electrical Transmission Convention.)—Notes on lightning. Mention is made of experiments in which three cameras, fixed in different parts of Washington, were directed upon the Washington Monument with the object of constructing a rough model of a flash. No results have been obtained so far. [See also Abstract No. 1836 (1900).] H. B.

768. *Experimental and Mathematical Physics.* **H. Poincaré.** (International Physical Congress at Paris, Report, 1. pp. 1–29, 1900.)—An able discourse on the relations between experimental and mathematical physics. Experiment is the unique source of facts, but facts alone do not constitute science any more than a heap of stones are themselves a building. Essential as the facts are, the generalisation that unites them is equally so, if we are to have a science worthy the name. The unity of nature, the *rôle* of hypothesis and the origin of mathematical physics are then dealt with, the significance of physical theories insisted upon and the advance of physics traced to the end of the nineteenth century. E. H. B.

769. *Properties of Solids under Pressure.* **W. Spring.** (International Physical Congress at Paris, Report, 1. pp. 402–431, 1900.)—This paper is a summary of the results hitherto obtained by the author and other observers in the examination of the behaviour of solid substances under high pressures. The properties dealt with include plasticity, elasticity, allotropic transformations, agglutination, diffusion, and chemical reactions in solids. References are given to the sources of information consulted. N. L.

770. *Transient Deformations of Solids.* **C. E. Guillaume.** (International Physical Congress at Paris, Report, 1. pp. 432–448, 1900.)—Transient deformations are produced, and disappear, slowly, and occupy a position intermediate between perfectly elastic deformations and permanent changes of form. Such are the displacement of the zero of thermometers, thermal and electric changes in certain alloys, phosphorescence, &c. The author gives a *résumé* of the phenomena hitherto observed and seeks their explanation in the theory that all substances exhibiting transient deformations are in a state of chemical equilibrium which varies with external conditions, and to which they slowly attain when these conditions are modified. N. L.

771. *Spectroscopic Results at Solar Eclipse, May 28, 1900.* **E. B. Frost.** (Astrophys. Journ. 12. pp. 307–351, 1900.)—Full tables are given of the lines reduced from the photographs of the spectrum of the chromosphere obtained during the eclipse with prismatic cameras, &c., and subsidiary discussions of the probable origins of many of the lines. C. P. B.

772. *Detection of Solar Corona in Daylight.* **G. E. Hale.** (Astrophys. Journ. 12. pp. 372–375, 1900.)—This paper gives a *résumé* of the results obtained during the last seven years in connection with the problem of detecting the existence of the solar corona, during full sunlight, with a bolometer. The whole of the thermal radiation is employed, in contrast to the work of Deslandres, who uses the infra-red rays only. Although much of the work has given negative results, the work done in 1900 gave promise and is being continued with the exceedingly sensitive Nichols radiometer at the Yerkes Observatory. C. P. B.

773. *Gyrostatic Pendulum Experiments.* **V. Dvořák.** (Phys. Zeitschr. 2. p. 224, Jan. 12, 1901.)—A few experiments with a gyrostatic pendulum are here described, one illustrates nutation, another the so-called polygonal pendulum, and the others conical pendulums with greatly increased and greatly diminished periods. J. B. H.

774. *Influence of Bending and Straightening on the Elasticity of Iron.* **M. Rudeloff.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 46–53, Jan. 12, 1901. Communicated by the Kgl. mech.-techn. Versuchsanstalt.)—In testing the strength of iron pipes a different result is obtained if the pipe is tested as a whole from that calculated from the results of tests made on a test specimen cut from the pipe. This may be due to the straightening to which the best specimen is previously subjected. The author has accordingly here investigated the influence of bending, straightening, and annealing on the elastic properties of iron. The results are given in tables and curves in the paper. J. B. H.

LIGHT.

775. *Electrodynamic Theory of Helmholtz and the Electromagnetic Theory of Light.* **P. Duhem.** (Archives Néerlandaises, 5. pp. 227–236, 1900.)—The writer refers to a former communication to the Faculty of Sciences at Bordeaux, 1899–1900, in which he had shown that Helmholtz' system leads to a complete electromagnetic theory of light. He here gives a brief account of the results obtained, with a view to a detailed exposition in future.

In the present paper he gives Helmholtz's fundamental equations. In a non-magnetisable medium, if v denotes the ratio between the coefficients of electrostatic and electromagnetic action, we have in Helmholtz's notation—

$$v^2 = \frac{\epsilon}{a^2(1 + 4\pi\epsilon F)}$$

If the medium be capable only of feeble magnetisation, the above expression becomes—

$$v^2 = \frac{\epsilon}{a^2(1 + 4\pi\epsilon F)(1 + 4\pi f)}$$

In a non-conducting dielectric, the velocity of propagation of a wave of longitudinal displacement is—

$$L = \frac{1}{a}\sqrt{\frac{1 + 4\pi\epsilon F}{4\pi K F}}.$$

That of a wave of transverse displacement is—

$$T = \frac{1}{a\sqrt{2\pi F(1 + 4\pi f)}}.$$

Maxwell's known laws are compared with these results of Helmholtz.

Helmholtz leaves K undetermined, remarking only that if while a^2KF remains finite, ϵF becomes very great, longitudinal displacements cannot exist—a conclusion at which Maxwell also arrives. But Duhem proposes in the present paper to modify this result, by so determining K as to make ϵ/a^2K finite.

For this purpose he investigates the phenomena of reflection and refraction at the interface of two media, when the incident wave is one (1) of longitudinal displacement, (2) of transverse displacement. The results obtained in the latter case agree with those of Fresnel.

The conclusions drawn are—(1) That it is possible, following Helmholtz's method, to give a complete theory of reflexion and refraction at an interface. (2) That by aid of the hypotheses of Faraday and Mossotti, the results may be shown to agree with the known laws of reflexion and refraction, although waves of longitudinal displacement are not excluded. S. H. B.

776. *Velocity of Light.* **A. Cornu.** (International Physical Congress at Paris, Report, 2. pp. 225–246, 1900.)—In this report the author describes briefly the toothed-wheel method by which he obtained the velocity 300·400 km. per sec., the revolving mirror method as modified by Michelson and Newcomb, and the method of Young and Forbes. He indicates as a fatal weakness in the last the use of a metallic mirror with a hole in the

centre, in place of the usual plate of unsilvered glass. Newcomb's method is spoken of as substantially identical with Michelson's, but with improvements in details [no mention being made of the changed position of the lens], and Newcomb's result 299·860 is adopted as representing the revolving mirror method. The half sum 300·130 of these two results is the final result adopted as most probable. [Since the communication of this report, Perrotin has obtained the value 299·900 by the toothed-wheel method. See Abstract No. 42 (1901).] A. E.

777. *Double Refraction in Transversely Vibrating Glass Plates.* **W. König.** (Ann. d. Physik, 4. 1. pp. 1–40, Jan., 1901.)—When transverse vibrations take place in an oblong glass plate with free ends and two or more nodal lines, there exists, answering to the periodic bending of the plate, a periodic double refraction of the same sort as that produced by the static bending of the plate. This paper contains an experimental and theoretical investigation of this double refraction.

In transversely vibrating glass plates two kinds of double refraction are observed. In the loops only the one kind is present, in the nodes only the other kind; at the intermediate positions both exist at the same time.

The double refraction which appears at the loops is caused by the curvature of the plate, and is of the same sort as that which is produced in known ways by static bending. Its axes lie in the direction of the length of the plate and at right angles to it; its intensity increases from the neutral middle line towards the edges, proportionally to the distance from the middle line, and the magnitude of the specific double refraction of the glass, as determined by these observations, is just as large as that found from observations on statically bent plates.

The double refraction existing in the nodes is originated by the shearing forces called into action in the plate by its bending. Its axes are at an angle of 45° to the length of the plate; its magnitude is small; it appears, answering to theory, to have its greatest value in the middle of the plate and to fall off towards the edges. Its relation to the amplitude of vibration of the plate agrees almost exactly with that value which results from theoretical calculation, if the expression given by Saint-Venant for the shearing forces in static bending is transferred to the bending of the vibrating plate. J. J. S.

778. *Double Refraction due to Stress.* **Rayleigh.** (Phil. Mag. 1. pp. 169–178, Feb., 1901.)—The stresses in an elastic solid due to unequal heating are here first of all theoretically considered, and then, by giving definite form to the body and definite temperature conditions, the state of stress as given by the equations is tested by experiment. If the body be of glass, or other similar transparent substance, the state of stress may be determined by examining the body between crossed Nicols and noting the double refraction. This is done for two cases. (1) A plate of glass 8 cm. square and 1 cm. thick has the opposite edges polished. When placed in the polariscope it shows but little revival of light so long as the temperature is uniform. The contact of the hands with the two faces suffices to cause an almost instantaneous illumination, rising to a maximum at the middle of the thickness after a few seconds. Dark bands situated about halfway between the middle and the faces are a conspicuous feature. After about 30 or 40 seconds the light fades greatly—a result more rapidly attained if the hands be removed after 10 or 20 seconds' contact. The varying conditions of stress indicated by these bands is in qualitative agreement with that deduced theoretically. (2) A short

length of glass rod in its natural imperfectly annealed condition is used to illustrate symmetrical stress. The nature of the stress present in the so-called *toughened* glass is also investigated experimentally.

The paper is of a mathematical nature, but these few particular examples illustrate the general problems of the stresses in slabs and rods with which it deals. J. B. H.

779. *Refraction within Telescope Tube.* **J. Renton.** (Nature, 63. pp. 334–335, Jan. 31, 1901.)—There has been much discussion over an unexplained discordance which is found in comparing the zenith-distance of a star obtained by direct observation with that obtained by observing it reflected in a pool of mercury. The author attributes this discordance to difference of temperature in the *stagnant air within the telescope tube.* The upper side of the tube is cooled by radiation, while the lower is protected, causing a transverse gradient of temperature in the air inside. The rays passing through the tube will thus be bent upwards, so that the Z.D. observed directly will be too great, and the Z.D. by reflection too small. The error is of peculiar importance from the fact that it affects to a relatively large amount the zenith-distances of polar stars, and hence the deduced results for latitude. The time of exposure in observing a north star is generally greater than for a south star, since the observation in right-ascension, which is made at the same time, takes longer in the case of a slow moving polar star. Another discordance found in the Greenwich observations may be similarly explained. When the north and south collimators are aligned by looking through the holes in the telescope-cube, the collimation error differs systematically from that obtained by aligning with the telescope raised out of the way. At the hour, 8 a.m., when these observations are made, one side of the instrument is generally warmer than the other. The conclusion is drawn that means should be used for circulating the air in the tube. A. E.

780. *Refraction Curves for Prisms.* **A. de Gramont.** (Journ. de Physique, 10. pp. 97-116, Feb., 1901.)—Curves for flint-glass prisms are given, and discussed, showing variation of—(1) index with wave-length, (2) deviation with incidence, (3) dispersion with incidence. The calculated numbers were checked by actual spectroscopic observation of certain bright lines. To get the angles of incidence, the position of the prism for normal incidence was first obtained thus :—A pocket lens, and a piece of unsilvered glass placed at 45°, were held before the slit, and the observer, looking through these down the collimator, brought the slit into coincidence with its image in the face of the prism. The second curve, in which $x =$ deviation, $y =$ angle of incidence, resembles a parabola placed obliquely. At the point corresponding to minimum deviation the ordinate becomes a tangent. The different curves corresponding to different wave-lengths all have their upper ends on a line ($y = 90$) parallel to the axis of x, and their lower ends on another line inclined at 45° ($y = x - 90 + A$). As A, the angle of the prism, increases, this line shifts to the left, and the arcs are shortened. Further, the points corresponding to minimum deviation of all the curves, lie on a third line $2y = x + A$, which bisects all chords parallel to the axis of y, and passes through the intersection of the first two lines. When $\mu \sin\frac{A}{2} = 1$ the curve shrinks to a point. A. E.

781. *Refractive Indices of Calcium Chloride Solutions.* **G. J. W. Bremer.** (Archives Néerlandaises, 5. pp. 202–218, 1900.)—According to M. B. Walter (Wied. Ann. 38. p. 107) the refractive index of a solution increases proportionally to its concentration. If n is the index of the saline solution, n_0 that of water for the same wave-length, then $(n - n_0)/p$ is constant, when p is the weight of anhydrous salt in 100 gm. of the solution. The author has extended this investigation to other wave-lengths than those considered by Walter, and has in especial determined the refractive power of solutions of different concentration for different wave-lengths. The refractive power is calculated by H. A. Lorentz's formula $(n^2 - 1)/(n^2 + 2)d$, when n is the refractive index and d the density. His conclusions are as follows :—(1) The refractive power of a solution of calcium chloride, for the same rays, does not depend upon its concentration, and it differs little from that of water. (2) The differences between the indices of refraction of a given solution of calcium chloride and those of water for the same rays are approximately the same for waves of different lengths. (3) For solutions of calcium chloride these differences are proportional to the amount of anhydrous salt dissolved in 100 gms. of the solution. D. E. J.

782. *Astigmatic Lenses.* **R. J. Sowter.** (Phil. Mag. 1. pp. 239–246, Feb., 1901. Paper read before the Physical Society of London.)—If we take a section of a lens surface perpendicular to the axis of the lens, we get a curve which we may call a natural aperture. If we take similar sections of similar lenses, each one at the same distance along the axis of the lens from the point where the axis meets the surface, then the powers of the different lenses are inversely proportional to the squares of the radii of these similar sections. In any one lens also where the section is not a circle, the power in any direction is inversely proportional to the square of the radius vector in that direction. The author applies this to astigmatic lenses in general and to the combination of two cylindrical lenses crossed at right angles and also crossed obliquely. J. B. H.

783. *Fading of Photographic Plates.* **W. J. S. Lockyer.** (Nature, 63. pp. 278–279, Jan. 17, 1901.)—The author points out that, in the case of stellar photographs, it is most important to prevent any fading of the image, as the fainter stars are discernible only in the negative, being lost in the process of reproduction. In some of Roberts's photographs the number of visible star images diminished by 35 per cent. in ten years. Crookes has published, in the monthly notices of the Royal Astronomical Society, a method of reviving these lost images and of preventing further fading. The plate is treated with a solution of pyrogallic acid and sodium carbonate, then with sodium hyposulphite, and after immersing in a clearing solution is toned in an ammonium sulphocyanide gold-toning bath. The deposit of gold is more permanent than the original silver image. G. H. B.

784. *Absorption of Light by Coloured Glass.* **R. Zsigmondy.** (Ann. d. Physik, 4. 1. pp. 60–71, Jan., 1901.)—Definite quantities of colouring oxide were added to ten or more kinds of glass of known composition, manufactured according to the same method at Jena. For these the absorption A was determined by a Glan spectrum photometer, A being taken as E/gS, where E, the extinction coefficient, is the reciprocal of the glass thickness for which intensity of transmitted light is to that of incident light as 1 : 10 ; g is the number of milligrammes of colouring oxide per gm. of glass, and S is the

sp. gr. of the glass. Several good curves with spectra are given, showing the absorption which takes place for varying wave-length for the different colouring materials added, viz., oxides of chromium, copper, cobalt, nickel, manganese, iron, and uranium. G. E. A.

785. *Electric Analogue to the Zeeman Effect.* **W. Voigt.** (Ann. d. Physik, 4. 1. pp. 197–208, Jan., 1901.)—The object of this paper is to show that Lorentz's theory of the Zeeman effect, when applied to direct electro-optical phenomena, leads to the same results as the author's treatment of the inverse phenomenon (see Wied. Ann. 69. p. 297, 1899) by the application of Kirchoff's principle. The well-known effects of a field of electric force on light passing through a transparent medium show that the simple equations in Lorentz's theory, $md^2x/dt^2 = -\kappa x$, &c., where κ is a constant, can only be true as a first approximation. By means of the next approximation to the elastic force $K = (\kappa + \kappa' r^2)r$, it is found that for an ion vibrating in a field of electric force (of amount R parallel to the axis of z) its periods of vibration along the co-ordinate axes are given by the equations—

$$\left(\frac{2\pi}{\tau_1}\right)^2 = \left(\frac{2\pi}{\tau_2}\right)^2 = \frac{1}{m}\left(\kappa + \frac{\kappa' e^2 R^2}{\kappa^2}\right), \quad \left(\frac{2\pi}{\tau_3}\right)^2 = \frac{1}{m}\left(\kappa + \frac{3\kappa' e^2 R^2}{\kappa^2}\right),$$

instead of by the equation $\left(\frac{2\pi}{\tau}\right)^2 = \frac{\kappa}{m}$ in the undisturbed state. Hence it follows from Lorentz's theory that a luminous source vibrating with period τ in an electric field emits in a direction parallel to the lines of force ordinary light of a slightly different period τ_1, but in a direction perpendicular to the lines of force it emits two beams of light, plane-polarised in perpendicular planes, and of periods τ_1, τ_3, where $\tau_3 - \tau = 3(\tau_1 - \tau)$. Thus the author's previous conclusions are confirmed. His previous theory had also led to the expression $D_0 + D_1 R^2$ for the dielectric constant, and for a medium with only one kind of electron (a in number per unit volume) there are now deduced the expressions—

$$D_0 = 1 + \frac{4\pi e^2 a}{\kappa}, \quad D_1 = -(D_0 - 1)\rho_1$$

where

$$\rho_1 = \frac{\lambda_1 - \lambda_3}{\lambda} = \frac{\kappa' e^2 \tau^2}{4\pi^2 m \kappa^2}$$

is the relative separation for unit field. The author applies his results and Quincke's investigations on electric double refraction to an estimation of the order of magnitude of the effect, concluding that, if the fall of potential in the field be 300 volts per centimetre, it might be about the 20,000th part of the interval between the two sodium lines, which would explain why no one has yet been able to observe the phenomenon. W. E. T.

786. *Internal Reflection in a Crystal with Rotatory Power.* **B. Brunhes.** (Archives Néerlandaises, 5. pp. 1–16, 1900.)—The effects of double refraction are here complicated by those of rotation. Quartz plates 2 mm. thick, cut at 45° to the optic axis, were employed. A ray traversing such a crystal in the direction of the axis gives rise to two rays on internal reflection, an ordinary and an extraordinary, and the difference of phase of these two produced by the reflection was examined. Total reflection at air was compared with partial reflection at alcohol. Generally, a ray on striking the crystal would be split into two. Since, for simplicity of result, it was necessary that the

internally incident ray should be unique, matters were so arranged that the entering beam was circularly polarised, and thus able to pass unchanged in the direction of the optic axis. It was found that the difference in phase between the two reflected rays (rectilinearly polarised) was the same for right-handed circular incident vibration as for left-handed. The case of oblique transmission also was investigated, for rays making a small angle with the optic axis. Here special difficulties arise from the fact that one definite elliptic vibration (right or left-handed) has to be given to the incident ray that it may pass in the required direction unchanged. The required ellipticity was determined for several values of the inclination of the ray to the axis. The results of the measures accord fairly well with those of calculations based on the principles enumerated by Gouy (Journ. de Physique, 2^e Serie, t. iv., p. 149, 1885). *Apparatus.*—The quartz plate forms the hypotenusal face of a right-angled isosceles liquid prism, whose other two sides are of glass. The liquid is a mixture of two vols. of benzine with one vol. of carbon bisulphide, its index being nearly the same as the ordinary index of quartz. On the side of the crystal, away from the prism, is a shallow chamber for air or liquid, divided in two by a cross partition, so that one half can be filled with air and the other with alcohol, and the reflections against these two media compared. A ray incident normally on one of the lateral faces of the prism emerges from the other after reflection at 45° at the interior surface of the crystal. As to the rest of the apparatus, a small pencil of solar light passes in turn through the following: a circular polariser, an achromatic lens, the prism and quartz where it is reflected at 45°, an analysing nicol, a lens, and the spectroscope. The circular polariser consists of a Nicol followed by a Fresnel's rhomb adjusted so that when the Nicol is set in the azimuth $P = 45°$ or $P = 135°$ the ray entering the prism is circular.

In general, where polariser and analyser have arbitrary orientation, the appearances are complicated. For simplicity, one of the two following plans was adopted: (1) The polariser was set at $P = 45°$ or 135°, and the analyser rotated. Then a score of bands are seen in the spectrum, which remain fixed in position, but alter in blackness or brightness. (2) The analyser was set at $A = 0$ or 90°, and the polariser rotated. Only one, unique, band is seen in the case of transmission parallel to the optic axis. This method was applied to oblique transmission, it being sought to determine for what two values of P the spectral bands had their maximum sharpness. One value is $P = 90°$; the other, $P = \phi$, varied with the incidence. The positions half-way between these give the proper azimuths of the polariser for obtaining a unique ray. By means of the bands in the spectrum, the difference of phase between the ordinary and extraordinary ray caused by passage through the quartz can be measured. In the case of total reflection at air, it was found that in passing from a right-handed circular incident vibration to a left-handed there was no displacement of the spectral bands, or rather the spectra were complementary. A similar remark applies to the two "privileged" elliptic vibrations (right and left-handed) in the case of oblique transmission. In comparing total reflection at air with partial reflection at alcohol a displacement of the bands was observed. For $A = 0°$ or 90°, and for $P = 0°$ or 90°, the light emerging from the analyser is coloured, green or purple, according as the nicols are crossed or parallel. Exactly the same tints are obtained by reflection at alcohol as by reflection at air. A. E.

787. *Magnetic Rotatory Polarisation.* **W. Wien.** (Écl. Électr. 25. pp. 114–115, 1900.)—The author criticises Brillouin's contention [see Abstract

No. 1124 (1898)] that the Faraday effect is no exception to the theorem of Clausius, and that at the same time it is an exception to the law of reciprocity in the path of luminous rays. The author believes that the two theorems of Clausius and Helmholtz cannot be separated. Let ds_1 and ds_2 be two equal elements of black surface which send each other rays. To calculate the radiation from ds_1 to ds_2, a cone is constructed upon every point of the element ds_1, and the radiation is—

$$e ds_1 \frac{ds_2}{r^2},$$

where e is a constant and r the distance between the elements. Similarly, the radiation from ds_2 upon ds_1 is—

$$e ds_2 \frac{ds_1}{r^2}.$$

These two expressions are equal whatever be the path of the rays, provided it is the same to and fro. But when the plane of polarisation is turned by magnetic forces, the paths are different, and the cones are no longer identical. The author describes a case in which the amount of radiation received by one surface may be three times the amount received by the other. E. E. F.

738. *Rotatory Power of Malic Acid.* **B. Woringer.** (Zeitschr. Phys. Chem. 36. pp. 336–357, Feb. 22, 1901.)—Plotting out the apparent specific rotatory powers as ordinates and the percentages (q) of water in the solution as abscissæ, we find for each colour that the curve is very nearly a straight line. We have for the different colours :—

Red ($\lambda = 665{\cdot}9\ \mu\mu$), $(\alpha) = +4{\cdot}605^\circ - 0{\cdot}071q$............	$q = 64{\cdot}96$ per cent.
Yellow ($\lambda = 591{\cdot}9\ \mu\mu$), $(\alpha) = +6{\cdot}544^\circ - 0{\cdot}096q$	68·41 „
Green ($\lambda = 533{\cdot}0\ \mu\mu$), $(\alpha) = +8{\cdot}349^\circ - 0{\cdot}113q$.........	74·02 „
Bright blue ($\lambda = 488{\cdot}5\ \mu\mu$), $(\alpha) = +10{\cdot}121^\circ - 0{\cdot}130q$	77·95 „
Dark blue ($\lambda = 448{\cdot}2\ \mu\mu$), $(\alpha) = +14{\cdot}971^\circ - 0{\cdot}173q$	86·56 „

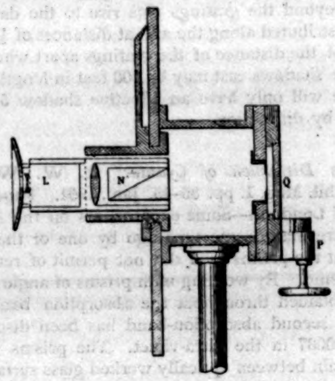
The last column shows the percentages of water in solutions which, for the respective colours, produce no rotation, the rotation for more dilute solutions being negative, to the left. Only wave-lengths shorter than $\lambda = 382{\cdot}0\ \mu\mu$ give positive rotations at all dilutions. The straight lines converge as the dilution increases, but they do not meet at any one point; there is, therefore, no "complete achromatism" (Nasini and Gennari, Zeitschr. Phys. Chem. 19, 115, 1896) at any dilution. There is, however, partial achromatism: the lines for red and yellow cross, and the rotations for red and yellow are equal, at 78 per cent. water; red and green at 89, red and bright blue at 93 (red and dark blue at 102 per cent.). At these respective percentages of water anomalies of dispersion appear, the red becoming less rotated to the left than the green, and so on for the others; so that at infinite dilution (α) has a maximum negative value for the yellow ($\lambda = 540$) not the red. The Biot-Boltzmann formula $(\alpha) = A/\lambda^2 + B/\lambda^4$ is sufficient for $q = 0$, and no terms in λ^6 are required. For each degree of dilution there is one colour the rotation of which is a minimum. In general, for a temperature of 20°,

$$(\alpha) = \frac{1{\cdot}178}{10^6 . \lambda^2} + \frac{0{\cdot}348}{10^{12} . \lambda^4} + \left(\frac{0{\cdot}02901}{10^6 . \lambda^2} + \frac{0{\cdot}000959}{10^{12} . \lambda^4}\right) q.$$

On finding the values of (α) for $q = 0$ and for $q = 100$ we may plot these and draw a straight line between them. The equation last given represents a surface of the third order, in (*a*), $(10^8 . \lambda^2)$, and *q*, the geometry of which is discussed; the anomalies referred to above represent a fold in this surface.

A. D.

789. *New Half-Shadow Polarimeter.* **J. M. de Lépinay.** (Comptes Rendus, 131. pp. 832–834, 1900. Also Journ. de Physique, Nov., 1900.)—The new apparatus satisfies two conditions essential to precision. It allows of the employment of any monochromatic radiation, and it preserves all its sensibility in converging light. The first condition has been fulfilled by using, for the production of the half-shadows, a thin quartz formed by two prismatic plates with opposite rotations, and with small and equal angles. This enables the observer to produce maximum sensibility whatever the wave-length of the light used. The second condition is of great importance. Since the optical properties of an anisotropic body vary with the direction, the solid examined must be terminated by plane surfaces and the phenomena must be observed by means of an astronomical lens focussed upon infinity. To each point of the focal plane of the object-lens there corresponds a single direction of propagation of the light through the body.



If then the phenomenon utilised is a phenomenon of polarisation, the analyser will be by preference introduced between the eyepiece and the focal plane of the object-lens, and the point of reference will remain fixed during the rotation of the analyser. If the analyser is an ordinary Nicol, all accurate observation becomes impossible, as it is traversed by a divergent beam. This is obviated by making the faces of the Nicol normal to the entering and emerging beam and parallel to the optical axis of the Iceland spar. A small Galilean telescope allows the observer to focus upon the plane of the quartz plate. The arrangement is shown in the diagram, where Q is the quartz plate, N the Ahrens prism which serves as an analyser, and L a Galilean telescope. The author has applied the apparatus to the measurement of the rotatory power of quartz for the green mercury line, and to absolute measurements of thickness by a modification of Mouton's method. E. E. F.

790. *Interference Phenomena.* **C. Barus.** (Science, 12. pp. 617–627, 1900.)—The author writes on the interferences observed on viewing one coarse grating through another, and on the projection of one piece of wire gauze by a parallel piece. The investigation was suggested by the common phenomena of waterlines seen on looking through two parallel picket fences, but these turn out to be very complex, and open to careful analytical treatment. If two gratings are placed at a distance apart along an axis, and the first illuminated by a strong diffuse light, the second will project a real image of the former grating at definite points on the axis, almost as if it were a zone plate. When these images are looked at by the eye in the proper position, they appear as magnifications of the first grating, often enormously large, the size increasing with the distance of the focal plane from the projecting grating. The indefiniteness of focus when viewed by the normal eye is due to its power of accommodation, and the size is an illusion, for the eye is adjusted for an infinite distance and locates the image of unknown position there. Direct projection is only possible in a darkened room and at the strongest focus, supposing that diffused daylight illuminates the first grating. With sunlight all the real foci may be projected, but the use of sunlight slightly alters the conditions. The author describes an arrangement for finding the focal planes by means of a lens placed in front of the eye, and also a diagram in which planes are laid through pairs of wires and their intersection in lines beyond the gratings give rise to the darkest spaces. The focal planes are distributed along the axis at distances of ½, 1, 2, &c., multiples and submultiples of the distance of the gratings apart when the two gratings are identical. The shadows cast may be 100 feet in length, while in sunlight a filamentary wire will only have an effective shadow 5 or 10 inches long. This is explained by diffraction. E. E. F.

791. *Anomalous Dispersion of Cyanin.* **R. W. Wood** and **C. E. Magnusson.** (Phil. Mag. 1. pp. 36–45, Jan., 1901. Paper read before the Physical Society of London.)—Some experiments on the Anomalous Dispersion of Cyanin were made some time ago by one of the authors [Abstract No. 661 (1899)], but the prisms used did not permit of readings being taken in the absorption band. By working with prisms of angle about $30''$, readings have now been obtained throughout the absorption band and also in the ultra-violet, and a second absorption-band has been discovered, beginning at wave-length 0·00037 in the ultra-violet. The prisms were prepared by pressing fused cyanin between optically worked glass surfaces by means of a screw press in a heated air-bath, and then breaking off one of the glasses when cool. Both spectrometer and interferometer methods were used, the latter with thin films of the dye instead of the thin prisms. In the ultra-violet the measurements were made photographically, and in all the experiments monochromatic light was obtained by means of a Rowland grating. The paper is accompanied by curves and photographs showing the dispersion.
J. B. H.

792. *Spectrum of Silicon.* **J. N. Lockyer.** (Roy. Soc., Proc. 67. 403–409, Jan. 19, 1901.)—Continuation of the work previously undertaken on the high-tension spark spectrum of silicon [Abstract No. 1022 (1900)] has resulted both in better determinations of the lines formerly seen and the discovery of several new ones. These latter are also found to agree with lines in stellar spectra, and the presence of all the silicon lines in the spectra of the stars α Cygni, β Orionis, γ Orionis, and ϵ Orionis is shown by a tabular statement giving the relative intensities in each case.

Four groups of lines are now recognised, each associated with a distinct temperature level when produced under laboratory conditions, and these data are applied to the plan of classifying stellar spectra into cyclical groups showing evolution of one class from neighbouring ones. C. P. B.

793. *Reversing Layer Photographed with a Concave Grating.* **J. F. Mohler** and **F. C. Daniel.** (Astrophys. Journ. 12. pp. 361–365, 1900.)—Account of an experiment made at the Solar Eclipse, May, 1900. A Rowland grating of 10 feet radius, with 14,400 lines to the inch, was used to form a diffracted image of the sun's crescent without the use of lens or slit, in the same way that an objective prism spectroscope is used. The lines of the grating were tangential to the sun's edge at the places of second and third contact. The sun's image was 0·56 inch in diameter. The partial success obtained leads the authors to believe that the instrument could be used to great advantage in photographing the spectrum of the flash. The results, however, were not so good as had been expected. About forty bright lines were obtained at the flash, but they were lacking in sharpness, and could only be measured to one Ångström unit. The blurring is ascribed partly to insufficient care in adjustment, partly to astigmatism. The effect of the latter is calculated from Mitchell's formula (Johns Hopkins Circular, June, 1898). A. E.

794. *False Spectra with Rowland Concave Grating.* **T. Lyman.** (Phys. Rev. 12. pp. 1–13, Jan., 1901.)—The author finds that several gratings he has used show abnormal spectra, which might be mistaken for true lines, falling in series with the lines of the normal spectrum. Photographs are given showing some of these false images in the spectrum of magnesium. The false lines are not so prominent in large gratings as in smaller examples. The author presents the following conclusions :—

(1) The first spectrum from the Rowland concave grating is not pure, but is complicated not only by underlying spectra of higher order, but by the presence of a number of spectra of lower dispersion than in the chief spectrum.

(2) The number and dispersion of these false spectra obey no simple law and differ with different gratings. C. P. B.

795. *Reproduction of Diffraction Gratings.* **Elihu Thomson.** (Science, 13. pp. 114–115, Jan. 18, 1901.)—This is a comment on a previous letter of R. W. Wood to the same journal, concerning the production of copies of diffraction gratings in bichromated gelatine and albumen. The method followed by Thomson is to silver a glass grating, then copper it electrolytically and separate by slightly warming. The surfaces of the metal copies are not perfectly plane. The author suggests a method of overcoming this. First silver the glass grating, then, having coated a flat glass surface with a thin layer of adhesive cement, like hard pitch or shellac warmed, or with a cement like glycerine and litharge which sets firmly, apply this to the silver surface and allow it to harden before separating from the glass. C. P. B.

796. *Transformations of Röntgen Rays.* **G. Sagnac.** (Soc. Franç. Phys., Bull. 157, pp. 2–3; Discussion, p. 3, 1901.)—The amount of secondary radiation gives a clue to the presence of active elements, such as iron or copper in aluminium. The absorption of secondary rays by the air is emphasised by the results of working *in vacuo*. Discussion of phenomena of discharge by air apparently ionised through the travel of ions, slow but analogous to the travel of particles in kathode rays. A. D.

797. *Energy, &c., of Röntgen and Becquerel Rays.* **E. Rutherford** and **R. K. McClung.** (Roy. Soc., Proc. 67. pp. 245–250, Nov. 14, 1900. (Abstract). Roy. Soc., Phil. Trans. 196. pp. 25–59, Feb. 27, 1901.)—On the assumption that all the energy of Röntgen rays is absorbed in producing ions in a gas, the total energy of the rays, divided by the total number of ions produced, would be a measure of the energy required to produce an ion. The energy of the rays was determined by means of the heating effect of a known proportion of these rays absorbed by a metal, a specially designed platinum bolometer being used. It appeared that the correction due to secondary rays was small, and that the assumption was justified that the energy of the rays stopped by the metal plate is transformed into heat in the plate. The number of ions was computed from the current produced by the ionisation of a known volume of the gas and the absorption of the rays in the gas, together with J. J. Thomson's value of the ionic charge. For the special bulb employed the total heating effect due to all the rays emitted from the front of the plate (omitting absorption in the glass, air, and screens) was 0·011 gramme-calorie per second; which, at 57 discharges per second and a duration of 10^{-4} second (Trouton, Brit. Assoc. Report, 1896) for the production of the rays at each discharge, gives a rate of emission of energy (while it lasts) of 1·95 gramme-calorie per second. (Compare the heating effect of sunlight normally incident, 0·035 gramme calorie per second). About 4·4 per cent. of the energy supplied by the rays was transformed into light by a platinocyanide barium screen, and 73 per cent. was absorbed by it. This enables the energy of the radiation of any particular bulb to be expressed in absolute measure by comparing the intensity of the light from the screen with that from a Hefner standard lamp, and measuring, electrically or photometrically, the absorption of the rays by the screen, by placing a portion of the screen to absorb the rays. If H is the number of calories given out per second by the rays, E the energy of the same in ergs per second, W the average amount of energy required to produce an ion, n the number of ions produced per second (supposing all the energy of the rays absorbed in the gas is due alone to the production of ions, either directly or through secondary radiations in the gas), i the maximum or saturation current through the gas when all the ions produced reach the charged electrodes before appreciably recombining, and ϵ the charge on an ion, we have $E = JH$, $nW = E$, and $i = H\epsilon$, whence $W = JH\epsilon/i$. In this $\epsilon = 6{\cdot}5 \times 10^{-10}$ electrostatic unit (J. J. Thomson); and H and i have to be found. The latter, i, cannot be directly measured, since the rays could traverse several hundred metres of gas before approximately complete absorption took place: but it can be calculated from the number of ions produced in a known small volume, together with the coefficient of absorption of the gas. The latter was ascertained by a null method. The absorption is approximately proportional to the pressure: and the coefficient (mean) is, in air, about 0·000279 per atmosphere pressure with the bulb employed (0·001 with a much softer bulb; 1·600 for uranium rays; 0·000457 in carbonic acid, with the bulb employed). The mean value of W, the energy required to produce an ion in air at atmospheric temperature and pressure, is $1{\cdot}90 \times 10^{-10}$ erg: twice this for a positive and a negative ion. The mean intensity I_1 of the radiation at the surface of the bolometer is given by $JH = 0{\cdot}98\, AI_1 (1 - \rho_1)$, where A is the area of the grid, and ρ_1 is the transmission ratio of the rays when passing through the platinum grid; which gave a mean value $I_1 = 127$ ergs. In carbonic acid the coefficient of absorption was 1·59 times what it is in air; the current (at 300 volts) was 1·43 times as great; the value of W for carbonic acid is $1{\cdot}59/1{\cdot}43 = 1{\cdot}11$ times what it is in air, but this is subject to corrections, which make the two values of W not very different from one another. Experimental results hitherto obtained tend to show that approximately the same energy is required to produce an ion whatever the gas. Like the absorption, the intensity of the ionisation is proportional to the pressure of the gas. The energy used up in the production of ions in an "electric wind" is about $\frac{1}{25}$ of the whole. The distance between the ions in a molecule works out at about $1{\cdot}1 \times 10^{-9}$ cm., about $\frac{1}{30}$ the diameter of an atom. The energy required to produce an ion in air is very much greater than that required to produce an ion in the electrolysis of water; about 60 times as great: so that in water the ions separated would be about two atoms apart. In regard to sparking, if V be less than 175 volts, more energy would be required to produce ions than would be supplied; this would therefore be a minimum sparking potential. But we cannot infer the energy required to produce an ion from the observed minimum potential: the phenomenon is too complex. The energy emitted per sq. cm. of uranium oxide surface is approximately 10^{-11} calorie per second; per gramme about 10^{-9} calorie per second. Thoria $1{\cdot}2 \times 10^{-11}$ per sq. cm. per sec., in addition to the energy of temporary radio-activity developed on all substances in its neighbourhood. Radium and polonium vary very much from sample to sample, not only as regards the intensity but also as regards the kinds of radiation: uranium seems constant, even in solution or chemical combination, and on recrystallisation in the dark. Probably the radio-activity of uranium is not confined to the surface, but is possessed by the whole mass of the substance. In ten million years, each gramme of uranium in pitch blende must have radiated at least 300,000 calories; and radium far more. To consider these substances as transformers of energy leads to many difficulties. Possibly the regrouping of the components of a molecule might explain the supply of energy: but hardly in the case of radium, should it prove to be persistent in its radio-activity. Whether this is so is not yet known. A. D.

798. *Bolometry in Vacuo.* **F. Kurlbaum.** (Phys. Zeitschr. 2. pp. 258–259, Jan. 26, 1901.)—With reference to the work of Rutherford and McClung [see preceding Abstract], and of Schöps on the determination of Röntgen radiation in absolute units, the author remarks that he had used the same methods (Wied. Ann. 65. pp. 746–760, 51. p. 591), and recalls that he had (Wied. Ann. 61. p. 419) pointed out the advantages of working *in vacuo.* Through (1) eliminating the loss of heat by air-conduction, (2) steadying the apparatus by eliminating air-currents, and (3) reducing the loss of heat to one-twentieth where the radiations impinge on polished platinum in the absence of air, the apparatus is made nearly fifty times as sensitive. The authors referred to would seem to have overlooked this advantage. A. D.

799. *Energy, &c., of Röntgen and Becquerel Rays.* **E. Dorn.** (Phys. Zeitschr. 2. p. 218, Jan. 5, 1901.—In reference to Rutherford and McClung's paper [see preceding Abstracts] the author refers to the work of himself (Wied. Ann. 63. 160, 1897), of Schöps (Zeitschr. für Naturw. 72. 145, 1899, bolometric method) and Moffat (Roy. Soc. Edin., Proc. 21. 430, 1898). Schöps's results are very similar to those of Rutherford and McClung. [In the full R.S. paper, R. and McC. refer to Dorn and Moffat.] A. D.

800. *De-ionisation of Air.* **E. Dorn.** (Phys. Zeitschr. 2. pp. 238–239, Jan. 19, 1901).—A suggested explanation of Villari's experiments [see Abstract

No. 1808 (1900)] on the de-ionisation of air (previously ionised by Röntgen rays) by passing it through a twisted metallic tube. The explanation is based on the difference which, according to J. Zeleny [see Abstract No. 2420 (1900)], exists between the velocities of the positive and negative ions. D. E. J.

REFERENCES.

801. *Extension of Laplace's Theory of Atmospheric Absorption of Starlight.* **A. Gleichen.** (Deutsch. Phys. Gesell., Verh. 2. 16. pp. 222–234, 1900.)

802. *The Connection between Refraction and Parallax.* **E. v. Oppolzer.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 578–582, 1900.)—The astronomical refraction is the correction which must be applied to the apparent distance in order to obtain the value which would be found supposing the earth's atmosphere absent. The author discusses the expression for this quantity and its connection with parallax, and calculates the small correction which must be made in the parallax of the moon with various values of the apparent zenith distance, on account of refraction. J. J. S.

803. *Stresses in Solid Bodies due to Unequal Heating, &c.* **Rayleigh.** (Archives Néerlandaises, 5. pp. 32–42, 1900.)—Paper similar to that referred to in Abstract No. 778 (1901).

804. *Theory of Two Lens Objective.* **K. Strehl.** (Zeitschr. Instrumentenk, 21. pp. 10–11, Jan., 1901.)—The optical problem solved in this paper is as follows:—Suppose the distances of the object and image from a two lens objective to be given, suppose also the kinds of glass to be fixed and the lenses to be of infinitesimal thickness; it is required to find the four radii of curvature of the faces to satisfy the usual equations representing the chromatic, spherical, and sine conditions. J. B. H.

805. *Light without Heat.* **R. A. Fessenden.** (Elect. World and Engineer, 37. pp. 24–26, Jan. 5, 1901.)—An interesting discussion of the present methods of producing light, concluding with a reference to the possibility of producing a cold light by chemical means. W. R. C.

HEAT.

806. *Expansion of a Hard Jena Glass.* **J. T. Bottomley** and **W. T. Evans.** (Phil. Mag. 1. pp. 125–128, Jan., 1901.)—The authors describe experiments which were rendered necessary by the construction of an air-thermometer of the Bottomley type, which should be capable of being used at high temperatures, above the softening point of ordinary English glass. The glass used for the volume-gauge was a very hard Jena glass, supplied by Messrs. Schott and Co. and termed by them "Verbrennungsröhrenglas." The cubical expansion of the glass was determined directly by the weight-thermometer method, the particular form of apparatus used being fully described. The results of several experiments gave for the cubic expansion the values 0·00177, 0·00182, 0·00183, 0·00181; and this very small expansion makes this particular glass specially suitable for thermometric purposes at high temperatures. W. C. H.

807. *Thermal Absorption by Atmospheric Water-vapour and Carbon dioxide.* **K. Ångström.** (Ann. d. Physik, 3. 4. pp. 720–732, 1900.)—The author made experiments at various altitudes in Teneriffe, to determine the absorption of the sun's rays by carbon dioxide. Two tubes 40 cm. long, closed by plates of rock-salt, were fixed side by side, one containing air and the other carbon dioxide. At one end of each was placed a thermo-junction, the two being connected in series and in opposition, so that no e.m.f. would be produced if the radiation through the two tubes was the same. The carbon dioxide tube never showed any absorption, though an absorption of 1·5 per cent. was capable of measurement. From Lecher's results an absorption of 6 per cent. was to have been expected. The author calculates the absorption of the earth's radiation from the curves of distribution of energy in the spectrum. Assuming the constant c in Wien's equation as 14,700, he draws curves for temperatures of 100°, 8° and — 72° C., and measures the areas of the carbon dioxide absorption bands at 14·0–15·5 μ and at 4·18 μ. For a source of heat at 100° C., the absorption would be from 12·5 to 19 per cent. of the whole radiation; the author concludes that the maximum possible absorption of the earth's radiation would be 16 per cent.

The author next measured the absorption by various thicknesses of water at altitudes of 360 m., 2,125 m., and 3,683 m. above the sea. The equivalent thicknesses of water at these altitudes were respectively 2·6 cm., 1·2 cm., and 0·7 cm. From Hann's equation he finds the transmission coefficient to vary from 0·952 to 0.976. Schukewitsch's measurements of the absorption yield transmission coefficients varying from 0·961 to 0·991. Calculations from the differences between the sun's actual spectral curve and its curve if radiating according to Wien's law show an absorption of from 20 to 30 per cent. G. H. B.

808. *Position of the Volume- and Energy-Surface of a Crystal and its Melt.* **G. Tammann.** (Archives Néerlandaises, 5. pp. 108–117, 1900.)—To determine the position of the curve in which the volume-surfaces of a crystal and its melt intersect, it is necessary to measure the differences of the two specific heats of the substance not only for points near the melting-point curve but also for the super-cooled liquid. For this purpose the author chooses benzophenone, which possesses the property of spontaneous crystallisation in only a small degree. The results of the measurements carried out are briefly as follows :—(1) The change of volume on crystallisation of benzophenone at 44·7° is found to be (*a*) 0·0914 and (*b*) 0·0936 c.c. per c.c. or, taking the specific gravity of the liquid at 44·7° as 1·0988, 0·0832, and 0·0852 c.c. per gramme of material ; the second value is probably nearer the truth than the first. (2) The isobaric curves of the crystal and its melt for a pressure of 1 kg. per square cm. intersect at about −88°. (3) The connection between pressure in kg. per square cm. and melting-point of benzophenone is expressed very nearly by the equations—

$$p = 36{\cdot}45\,(t - 48{\cdot}1) + 0{\cdot}087\,(t - 48{\cdot}1)^2.$$

or—

$$t = 48{\cdot}14 + 0{\cdot}02757p - 0{\cdot}00000136p^2.$$

(4) The change of volume Δv on the melting-point curve diminishes proportionally as the temperature increases ; $\Delta v = 0{\cdot}0833 - 0{\cdot}00044\,(t - 48{\cdot}1)$. (5) The latent heat of fusion of benzophenone increases by 0·2 per cent. per 1°, while the change of volume on melting diminishes by 0·5 per cent. per 1°. (6) The isothermal variations of Δv are, other conditions being equal, larger than the variations of Δv on the melting-point curve, and diminish as the temperature falls. From the data obtained the author shows how the projection of the curve of intersection of the two volume surfaces can be approximately traced. T. H. P.

809. *Unit of Thermal Capacity.* **T. W. Richards.** (Zeitschr. Phys. Chem. 36. pp. 358–360, Feb. 22, 1901.)—The word "calorie" has become of uncertain meaning in the absence of an explanation on each occasion, on account of the variations in the specific heat of water. The expression of heat in c.g.s. units is hampered by this, that the unit of temperature has no relation to the c.g.s. system. The ideal would be—(thermal capacity $\times\,\delta\tau$) = Joules. It would not be convenient to graduate thermometers in degrees each about $\frac{1}{4\cdot2}$ °C. ; for the graduation would have to be altered at each determination of the mechanical equivalent of heat. If we took, instead of a gramme of water, a gramme of magnesium for temperatures about −50°, or a gramme of aluminium for about 290°, or a gramme of magnesium containing about 5·5 per cent. Zn for ordinary temperatures, we would have a unit of capacity equal to about $\frac{1}{4{\cdot}181}$ calorie, which might be called a "Mayer," the c.g.s. Centigrade unit. This would work out well in detail, with the aid of a kilomayer (*kmy*) and would be useful not only in entropy but also particularly in electrochemical problems. A. D.

810. *Melting-Point of Gold.* **L. Holborn** and **A. Day.** (Ann. d. Physik, 4. 1. pp. 99–103, Jan., 1901. Communicated by the Phys. Tech. Reichsanstalt.)—The results are given of several series of determinations of the melting-point of a mass of 450 grammes of pure gold by the crucible method. The gold was heated by means of an electric furnace, the temperature being measured by the same thermo-element as was previously used by the authors in determining the melting-point of gold by the wire-method, in which 1 cm. of gold wire was fused at the junction of the thermo-element. The mean values of the melting- and solidifying-points for the different series are as follows : (1) Using an ignited graphite crucible with walls 5 mm. thick, 1063·5°. (2) The same as (1), but with a current of carbon dioxide passing into the metal, 1063·5°. (3) Using a double porcelain crucible with asbestos packing between, 1063·3°. (4) Same as (1) or (3), but with a current of oxygen passing into the metal, 1063·5°. The curves showing the alteration of temperature with time do not show very good agreement. This is especially noticeable when oxygen is passed into the gold, in which case the stationary condition is by no means well defined, but the temperature rises considerably above the melting-point, to which it falls later. A piece of the gold used in the above measurements was drawn out into wire and employed for the determination of the melting-point by the wire method, the mean value obtained being 1063·9°. T. H. P.

811. *Automatic Temperature Regulator.* **C. T. Knipp.** (Phys. Rev. 12. pp. 47–49, Jan., 1901.)—An oven was electrically maintained at a constant temperature up to 380° C. for days together by two radiator coils, the fine adjustment of temperature being controlled by a copper iron thermostat. The temperature acts through a number of aluminium levers upon the contact of a relay. A curve of temperature fluctuations is given. M. O'G.

812. *Comparison of Thermometers of Different Glasses.* **F. Grützmacher.** (Phys. Tech. Reichsanstalt, Wiss. Abh. 3. pp. 229–268, 1900.)—A comparison is here made between eighteen thermometers, made between the years 1825 and 1888 by well-known makers. The experiments have extended over seven years to ensure that no continuous creeping of the zero points was taking place. The depression of the ice-point is determined for each thermometer after being kept for considerable time intervals at constant temperatures up to 100° C. The thermometer scales are also compared with the hydrogen scale.

The chemical compositions of the glasses are then compared, with the view of finding what constituents cause the greatest deviations from the hydrogen scale, and the greatest ice-point depressions. It appears that glasses which contain both potassium and sodium oxides are bad, and the more the proportion of these oxides present tends towards equality, the worse the glass becomes. The amounts of the reduction to the hydrogen scale and the depression of the ice-point seem to depend similarly on the chemical constituents of the glass, so that a determination of the ice-point depression suffices to measure the suitability of a glass for thermometric purposes. The best glass for thermometric purposes among those tested is the Jena glass No. 59^{III}. J. B. H.

813. *Capillary Error in Mercury Thermometers.* **C. E. Guillaume.** (Soc. Franç. Phys., Bull. 159. p. 3; Discussion, pp. 3–4, 1901.)—The angle of contact of the meniscus with the glass is found to depend upon the direction of the change in temperature. If, after a lowering of the level of the mercury, a feeble rise in temperature occurs, the angle of contact changes and the meniscus may not be displaced, the capillary pressure being altered, and therefore the volume of the bulb being so changed as to mask the increase in the volume of the mercury. Determinations of the amount of the error for various places in the tube show that variations in the error are due to differences in the surface of the glass. Owing to this error it is useless to increase the length of the degree beyond a certain limit.

In the discussion **Ponsot** referred to direct determinations of the correction for internal pressure made from readings taken with the thermometer alternately vertical and horizontal. The maximum of the curve of this correction agreed with the places where the equivalent lengths were greatest in the tube, and therefore he concluded that there was no capillary error of sensible amount arising from the variation of capillary pressure. In reply, **Guillaume** insisted on the necessity for applying to observations the correction for calibration before submitting them to other calculations. W. E. T.

814. *Pyrometry.* **C. Barus.** (International Physical Congress at Paris, Report, 1. pp. 148–177, 1900. Part reprint from the Bull. of the U.S. Geological Survey, Washington, 1889.)—A historical account is given of the methods of pyrometry, especially the recent devices for the accurate measurement of very high temperatures. The important researches by Holborn and Wien, and by Holborn and Day are referred to. For temperatures of 1,000° or over, the correction required in the stem of the porcelain air thermometer is doubtful.

The author discusses the errors inherent in the air thermometer at constant volume, and those belonging to the constant pressure air thermometer, and then refers to Regnault's gas thermometer depending on displacement, and to the attempts of Barus and Callendar to utilise the increase of the viscosity of gases. The viscosity being independent of the pressure, whilst viscosity and volume both increase with temperature, the velocity of passage of gases across tubes of platinum is a criterion doubly sensitive to variation of temperature.

Optical methods and electrical instruments are then described, and in conclusion the author states that the present condition of pyrometry is most encouraging, and that in a few years it will possess a series of constants as exact as those of the best developed branches of Physics. Nernst has discovered that refractory earths become conductive at high temperatures, so that it has become possible to heat electrically the most infusible substances up to the highest points of the scale. J. J. S.

815. *Latent Heats of Vaporisation of Organic Compounds.* **W. Louguinine.** (Comptes Rendus, 132. pp. 88–89, Jan. 14, 1901.)—The following are the mean results of the author's measurements of (1) Specific Heats: Aniline, 0·5485 (between 20·5° and 176·5°); methylethylacetoxime, 0·6508 (between 21·9° and 151·5°); anisol, 0·4806 (between 20° and 151·7°); butyronitril, 0·5471 (between 21° and 118·8°). (2) Latent Heats of Vaporisation: Aniline, 104·17, which gives a value of 21·19 for Trouton's ratio of molecular latent heat to the absolute boiling-point; methylethylacetoxime, 115·73, the corresponding value for Trouton's formula being 23·7; anisol, 80·30, giving 20·58 for Trouton's formula; butyronitril, 115·25, Trouton's number being 20·37. The values obtained for Trouton's formula show that in the case of aniline, anisol, and butyronitril, the liquid molecules are not polymerised to any appreciable extent, whilst the high value obtained for methylethylacetoxime indicates that its liquid molecule is polymerised to a considerable degree. Experiments previously carried out on alcohols and organic acids show that molecules containing a hydroxyl group in combination with a carbon atom suffer polymerisation in the liquid state, and the fact that the same is found to hold in the case of methylethylacetoxime shows that polymerisation also occurs with liquid molecules in which there exists a hydroxyl group combined with a nitrogen atom. [See also Abstracts Nos. 921 (1898), and 1038 (1900).]

T. H. P.

816. *Vapour Pressure of Water between* −12° *and* +25°. **M. Thiesen** and **K. Scheel.** (Phys. Tech. Reichsanstalt, Wiss. Abh. 3. pp. 71–94, 1900.) —This is the first of a series of investigations into the pressure of saturated water-vapour at different temperatures undertaken by the Reichsanstalt. The object of the present investigation was to determine the vapour pressure at 0° C., but some readings were also taken at temperatures varying from −12 up to +25° C.; these determinations, however, have not the same accuracy as that for 0°.

The method adopted is a direct manometric one, the water at the required temperature being in communication with one limb of the manometer and the other limb being connected with a vessel containing phosphorous pentoxide. The whole apparatus was carefully exhausted so that only water vapour was present. The method adopted for reading the level of the mercury surfaces in the manometer was that used in a former investigation [see Abstract No. 479 (1901)], and consisted in measuring microscopically the distance between a mark on the glass and its image in the mercury surface. It is quite impossible to give here the details of the investigation and the precautions taken, which were of that supreme order common to Reichsanstalt work.

The final result for the pressure of saturated water vapour at 0° C.

$= 4{\cdot}579 \pm 0{\cdot}001$ mm. of mercury at 0° and normal gravity.

$= 0{\cdot}006025$ atmospheres.

The means of the other observations are as follows:

Temperature.........	14·5679	15·0593	19·8402	16·3603	19·8438	25·4748	24·9749	−6·561	−11·334
Pressure...............	12·4385	12·8285	17·3622	13·9189	17·3411	24·3308	23·6818	2·6731	1·9217

These numbers are compared with a formula deduced in a previous paper by one of the authors [see Abstract No. 806 (1899)]. J. B. H.

817. *Determination of Specific Heats.* **W. Louguinine.** (Journ. de Physique, 10. pp. 5–19, Jan., 1901.)—The apparatus described, which is suited for the determination of the specific heats of both solids and liquids, is a modification and development of Louguinine's oven for use with the ice calorimeter (see Annales de Chemie et de Physique, 5ᵉ series, vol. xxvii. p. 398). In most calorimetric processes the method adopted is the following: The oven and boiler being fixed to bring the calorimeter up to them, allow the substance to drop from the oven into the calorimeter, and then remove it out of the range of possible radiations from them. In the instrument of Louguinine the calorimeter remains fixed, while the oven (and with it the boiler) can be brought up by means of a car running smoothly upon a pair of rails, which allow of its being removed to a distance of over a meter from the calorimeter when required.

When an observation is to be made by the former method, the temperature of the water in the calorimeter must be taken, the stirrer detached from the apparatus which keeps it in motion, the calorimeter brought up to the oven, the substance received in it, the calorimeter returned to its former position, the stirrer again attached, and finally the temperature read upon the thermometer placed in the water. There is a possibility of the water being cooled during its passage through the air, which must of necessity be fairly rapid, as the operation has to be done in as short a time as possible; there is a chance of spilling the water in the transit, and the time taken to attach the stirrer is also a drawback. With Louguinine's instrument, where the required temperature has been attained in the oven, it is run up on its rails so that its central cavity in which the substance under experiment is lying stands directly over the calorimeter. The thermometer in the calorimeter being watched all the time, and the stirrer keeping the water in motion, the substance can be allowed to drop into the calorimeter from the oven by pressing a button, the door at the bottom of the oven opening automatically to allow it to pass; the oven is then at once removed, and the indications of the thermometer carefully noted.

To the car which carries the oven are also attached a boiler and a condenser for the heating substance, the condensed vapour being returned again to the boiler. As heating liquids, various substances may be used according to the temperature required.

The substance under experiment, if solid, is made into an ovoid shape; if liquid, it is placed in a vessel of platinum of known capacity for heat, and also of an ovoid shape, to avoid splashing of the water as it drops into the calorimeter. Diagrams of the apparatus are given showing its minute construction, and tables of results obtained with it are also shown.

W. C. O.

818. *Molecular Heat of Compounds, and the Law of Neumann, Joule, and Kopp.* **E. van Aubel.** (Journ. de Physique, 10. pp. 36-37, Jan., 1901.)—Meyer's statement [Abstract No. 1434 (1900)] that the molecular heat of a compound is equal to, greater, or less than, the sum of the atomic heats of the elements according as the molecular volume is equal to, greater, or less than, the sum of the atomic volumes, does not hold in the case of AgBr and KI, which have a smaller molecular volume but a larger molecular heat; nor in the case of mercurous and mercuric iodides, which have a larger molecular volume but a smaller molecular heat. Amongst alloys that of antimony and iron, which is formed with a decrease of volume, shows an increase of heat capacity.

T. M. L.

819. *Specific Heat of Gases.* **A. Battelli.** (N. Cimento, 12. pp. 300-314, 1900; Intern. Phys. Congress at Paris, Report, 1. pp. 682-696, 1900.)—Both C_p and C_v vary considerably with the pressure: references are made to Joule and Thomson, Lussana, Leduc, Donnini, De Heen, Margules, Joly, Witkowski, Linde, Amagat; the law of the variation is still obscure, but there appears to be a maximum value of C_p at 350 atmos. (Amagat), 395 (Lussana). At constant pressure the specific heat also varies with the temperature (Lussana, Joly, Witkowski, E. Wiedemann, Winkelmann, Wüllner). Variations in vapours, hydrogen in palladium, the ratio C_p/C_v, and the velocity, &c., of sound are referred to along with the work of numerous investigators; as to the variations of C_p/C_v with temperature and pressure the results (Müller, Kundt, Wüllner, Cohen, Leduc) seem discordant but appear to show that there are variations of which the law is still obscure.

A. D.

820. *Determination of Critical Constants.* **É. Mathias.** (International Physical Congress at Paris, Report, 1. pp. 615-667, 1900.)—This paper contains a valuable account, descriptive and critical, of the various methods which have been employed for the determination of any or all of the critical constants of homogeneous substances and of mixtures. It is followed by a note on the optical method, and the phenomenon of Cagniard-Latour. The author shows that the fact that the meniscus between a liquid and its saturated vapour disappears at various mean densities, the ratio of the volumes (v and

v') of the liquid and vapour differing from unity, proves the necessity of introducing the notion of the Cagniard-Latour phenomenon into the theoretical calculation of v/v'. The formula then arrived at shows that for substances, whose mean densities have corresponding values, the phenomenon occurs at corresponding temperatures for which the ratio v/v^1 is the same, and suggests a new method of obtaining accurately the critical density and temperature, dependent on an approximate knowledge of the latter and on the measurement of v/v' when the meniscus disappears. The author estimates the possible error in the method, points out the special precautions to be adopted in its use and various questions worthy of experimental study, and shows its advantages over the similar method of Stoletov (Phys. Revue de Graetz. t. ii. pp. 69–73, 1892). In conclusion he shows that if the temperature at which the meniscus vanishes be a function of the mean density of the body in the tube it cannot be a function continually increasing or continually diminishing. W. E. T.

821. *Specific Heats of Fluids.* **P. Duhem.** (Comptes Rendus, 132. pp. 292–295, Feb. 11, 1901.)—The author considers the elements of a fluid as subject to general mutual reactions, and extends to this case the ordinary thermodynamical theorems. Thus, for a fluid in stable equilibrium, he proves the specific heat at constant pressure greater than that at constant volume and demonstrates the equations in the ordinary notation,

$$\left(\frac{dv}{dp}\right)_{\phi}=\frac{C_v}{C_p}\left(\frac{dv}{dp}\right)_{T}$$

and, for an adiabatic transformation,

$$\delta T=\frac{T}{JC_p}\left(\frac{dv}{dT}\right)_{p}\delta p.$$

W. E. T.

822. *Theory of Radiation.* **W. Wien.** (Ann. d. Physik, 4. 2. pp. 422–424, Feb., 1901.)—Planck's criticism of the author's former paper is here dealt with [see Abstracts Nos. 504 and 505 (1901)]. The difference between the writers disappears when a strict definition of an irreversible process is given. The problem of the radiating element at the centre of a reflecting hemisphere is strictly reversible if the element has infinitesimal dimensions. If, however, the element has finite dimensions, then the paths followed by all rays between the two spherical surfaces will not be equally long and the conditions at the instant of removing the inner sphere will be only approximately realised periodically, but if sufficient time is allowed the approximation may be as close as one pleases.

With regard to the problem of the magnetic rotation and the seeming contradiction of the second law of thermodynamics, the author considers that a strict investigation of the total radiation from the two bodies is desirable.

Jahnke, Lummer, and Pringsheim have objected to the author's suggestion to separate the law of radiation as applied to short and long waves. The author considers that deviations from the theoretical law, which is founded on molecular hypothesis, must occur with increase of temperature at smaller and smaller wave-lengths, and that with sufficient rise of temperature, those effects, which cause the deviations for long waves at low temperatures, can be made to affect any wave-length. J. B. H.

823. *Distribution of Energy in the Spectrum of a Black Body.* **E. Jahnke, O. Lummer,** and **E. Pringsheim.** (Ann. d. Physik, 4. 1. pp. 225–230, Jan., 1901.)—Critical discussion of Wien's formula; conclusion that the same is not in accord with the facts, is not well founded, and implies a temperature function which it is supposed to be devoid of. A. D.

824. *Formula for Pressure in a Gas.* **L. Boltzmann.** (Archives Néerlandaises, 5. pp. 76–77, 1900.)—If the volume actually occupied by gas molecules does not vanish in comparison with the space in which their motion takes place, the formula for the pressure, which for molecules of infinitely small dimensions would be T/v, requires a correction, which van der Waals expresses by using $v-b$ for v. Boltzmann refers here to Lorentz's treatment of the same subject, and to his own treatment in the Vorlesungen über Gas Theorie, Part II. pp. 7 and 167. He says here that his own method gives a complete value for the second term in the correction. But the integration being heavy is not yet completed. S. H. B.

825. *Theory of Gases.* **M. Reinganum.** (Phys. Zeitschr. 2. pp. 241–245; Discussion, p. 245, Jan. 19, 1901. Paper read before the 72nd Naturforscherversammlung at Aachen.)—Some difficulties may, it is suggested, be got over by the following theory:—Assume (1) the impacts between molecules are elastic and practically momentary; (2) the attractive forces are continuous but are negligible at any measurable distances, and are also independent of the mutual velocities; (3) these forces only come into play when molecules are at close quarters, the more so the greater the pressure, in which case the compensation of such forces all round a molecule begins to apply; (4) the deviation of molecules by attractive forces is less the higher the temperature; (5) the sum of the energies of the molecules remains constant. On this basis we find—

$$\left(p+\frac{f(c/T)}{v^2}\right)\left(v-be^{c/T}\right)=RT,$$

where $f(c/T)$ is a function depending only on the law of action of the forces, and $e^{c/T}$ is the ratio in which the number of impacts is increased by the attractive forces. The equation for internal friction becomes—

$$\eta=\frac{0{\cdot}3503\,.\,\rho\,.\,u}{\sqrt{2}\,.\,N\pi\sigma^2e^{c/T}}$$

One leading result of the mathematical development which follows is that the molecular diameter is set free from dependence on the temperature. A mean value for c (setting hydrogen aside) is 0·58. The results are traced out in various particulars, including the theory of electrons. A. D.

826. *Gaseous Diffusion.* **M. Brillouin.** (International Physical Congress at Paris, Report, 1. pp. 512–530, 1900.)—After pointing out the serious difficulties that attend experiments at other than ordinary temperatures, the author points out that the very act of putting the diffusing gases into communication causes an initial disturbance which can be experimentally demonstrated, and he suggests that this disturbance may be equivalent to a diffusion for some determinable interval. He then discusses Waitz's experiments and Hausmaniger's examination of them, and shows that they really lead to a coefficient of diffusion which, in opposition to O. E. Meyer's view, is in-

dependent of the concentration if the mode of opening communication has advanced the diffusion by a few seconds (15 to 24 in different series) and if distances are measured from a *vena contracta* about 2 mm. away from the actual orifice. He next submits von Obermayer's experiments to criticism, and finds in them, as in Waitz's experiments, no reason for thinking that the coefficient of diffusion of two gases depends on the ratio of the gases in the mixture or on any other circumstance than the uniform temperature and uniform total pressure of the mixture. His final conclusion is that Maxwell's train of reasoning is perfectly rigorous. R. E. B.

827. *Kinetic Theory of Gases and Carnot's Principle.* **G. Lippmann.** (International Physical Congress at Paris, Report, 1. pp. 546–550, 1900. —The author condemns Maxwell's suggested contravention of Carnot's principle by a sorting demon, since an opening to allow the passage of only a single molecule of air must be of molecular dimensions only, *i.e.*, of the dimensions of the intermolecular passages in the walls of the containing vessel, which yet are airtight. Maxwell's contention, nevertheless, that by dealings with molecules the principle may be contravened, is true, and three illustrations of this action are given. The author concludes that the phenomena of heat cannot be explained mechanically; the mechanical theory of heat, indeed, affords an easy interpretation of the principle of equivalence, viz., the existence of a linear relation between a quantity of heat and a quantity of mechanical energy, but it does not necessarily follow that these quantities are of the same nature, even as kinetic and potential energy, which are respectively dependent on, and independent of, time, are not to be confused with each other. R. E. B.

REFERENCES.

828. *Kinetic Theory of Gases.* **Gyözö Zemplén.** (Ann. d. Physik, 3. 4. pp. 761–763, Dec., 1900.)—A short mathematical discussion in continuation of the points at issue between S. H. Burbury and the author as to the fundamental hypotheses of the kinetic theory of gases. [See Abstracts Nos. 1817 (1900), and 85 (1901).] E. H. B.

829. *Laws of Fluids.* **E. H. Amagat.** (International Physical Congress at Paris, Report, 1. pp. 551–582, 1900.)—The variations of the product pv for a fluid with changes of p and t are exemplified by the author's own curves for CO_2, H_2 and N_2, and a series of general laws regarding the minimum values of pv, the pressure-coefficient $\partial p/\partial t$, the compressibility, isopiestic dilatation, isometric change of pressure, are deduced, the anomalous case of water being separately considered. van der Waals' characteristic and its modifications are then mentioned, and his theory of corresponding states is given in fair detail together with the results deduced later by others. Consideration of the critical state is entirely excluded. R. E. B.

830. *Radiation and Absorption.* **Rayleigh.** (Phil. Mag. 1. pp. 98–100, Jan., 1901.)—Historical. J. B. H.

831. *Solar Calorimeter for Eclipse Observations.* **J. Y. Buchanan.** (Cambridge Phil. Soc., Proc. 11. pp. 37–74, Jan. 30, 1901.)—The paper describes a series of experiments with a steam calorimeter used for determining the amount of solar radiation actually received at the surface of the earth, in distinction to the measurement of the "*solar constant.*" Very minute details are given, describing the geometrical construction of mirrors designed to reflect light along a focal line of given length. C. P. B.

SOUND.

832. *Refraction of Sound by Wind.* **E. H. Barton.** (Phil. Mag. 1. pp. 159–165, Jan., 1901. Paper read before the Physical Society of London.) —The refraction of sound by wind, where the rays are everywhere but slightly inclined to the wind, has been discussed by Rayleigh ("Sound," vol. ii. pp. 132–134), who obtains an approximate expression giving a result which differs only very slightly from the strict value in the numerical illustration used. On the ground of the theoretical interest of the wave propagation in this case, the author now makes a fuller examination of the problem on the basis of Huyghens' principle of wavelets and envelopes. W. C. H.

833. *Production of Beats.* **G. Athanasiades.** (Ann. d. Physik, 3. 4. p. 753, 1900.)—When two open organ-pipes of the same pitch are blown by the same air current, beats may be produced by introducing into the open upper end of one of them a small gas-jet directed vertically downwards. The frequency of the beats, and hence also the difference of pitch, increases with the length to which the gas-jet penetrates downwards. A similar effect may be produced by approaching a gas-flame to the mouth of the organ-pipe. E. E. F.

834. *Apparatus for the Study of Aerial Vibrations.* **F. L. Tufts.** (Amer. Phys. Soc., Bull. 1. pp. 61–62, 1900.)—The aerial disturbances are made to set a stretched membrane in vibration, and its motions are observed in the following way:—To the centre of the membrane is attached a small rectangular piece of tinfoil perpendicularly to its surface, and in this tinfoil a slit is made parallel to the plane of the membrane; a microscope is focussed upon this slit (which is strongly illuminated from the opposite side), and a micrometer in its eyepiece serves to measure the amplitude of vibration of the slit and hence of the membrane.

The apparatus takes two forms, one which is suitable for the measurement of alterations in the density of the air, having its membrane stretched over a globular-shaped resonator; the other, which may be used to measure the amplitude of the vibrations taking place, has its membrane stretched upon a brass ring. The membranes are mounted so that they can be turned about in any direction, and thus the component vibrations in these directions ascertained. The apparatus has been used to verify the law of inverse squares; in the determination of the relative opacity of various substances to sound, and other determinations. W. C. O.

REFERENCES.

835. *Physical and Psychophysiological Effects of Musical Impressions.* **F. Larroque.** (Comptes Rendus, 132. pp. 330–331, Feb. 11, 1901.)—A short note on the author's theories concerning the physiological effects of vibrations. R. S. W.

836. *Architectural Acoustics.* **W. C. Sabine.** (American Architect, 1900, Reprint, pp. 3–68.)—This is the first part of a work dealing with the design of theatres and lecture-halls in accordance with the best acoustic principles. This part deals with the reverberation, with especial reference to the absorbing power of wall-surfaces and of the audience. The author describes a method of measuring this absorbing power by the rate of decay of the original sound, and indicates how to calculate the acoustic properties of a hall beforehand. E. E. F.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

837. *On the Action Experienced by a Charged Conductor in a Field of Constant Intensity.* **V. A. Julius.** (Archives Néerlandaises, 5. pp. 17–31, 1900.)—A system of conductors is supposed to be placed in a uniform field. Green's integration is applied to the infinite space external to them all. With the usual notation, V denoting potential, dS an element of surface of a conductor, dn an element of the normal measured inwards towards the conductor, x any arbitrary direction, the author finds for a great number of conductors—

$$\Sigma\int\frac{dV}{dx}\frac{dV}{dn}dS=0,$$

Σ denoting summation over all the conductors. Similarly—

$$\Sigma\int\left(y\frac{dV}{dz}-z\frac{dV}{dy}\right)\frac{dV}{dn}dS=0.$$

He next considers the case of a single sphere placed without charge in the uniform field, of force parallel to x. This may be regarded as a sphere in the interior of which the density is uniform, and equal to ρ, called the positive sphere, coincident with another similar sphere (the negative sphere) within which the uniform density is $-\rho$, and the positive sphere is then displaced through the infinitely small distance dx. By this method the properties of the spherical conductor are deduced. Next is considered the case of a spherical conductor P, with charge hP, and a conductor of any shape Q, with charge hQ, placed at a distance from each other very great compared with the linear dimensions of either. This gives the results—

$$-\frac{k}{4\pi}\int\frac{dV}{dx}\frac{dV}{dn}dS=-bhQ,$$

the direction x being that of the field surrounding P. Here k is the dielectric constant, and b the intensity of the field surrounding Q. This shows that the action on Q is reduced to a single force in the direction of the field surrounding Q, equal to the product of the charge and the intensity of the field. The writer finally compares his own results and those of Lorentz's theory (Versuch einer Theorie der electrischen und optischen Erscheinungun Leyden, 1895). According to the theory of this paper, the action on a charged conductor placed in a field of uniform force can be reduced to a force in the direction of the field applied at the centre of inertia of the charge. S. H. B.

838. *Vibration Amplitude of Electrons.* **W. Kaufmann.** (Archives Néerlandaises, 5. pp. 148–151, 1900.)—The author obtains 10^{-8} cm. as a major limit for the amplitude of vibration of an electron, probably much in excess of the true value. He expresses the kinetic energy of the electron, supposed vibrating circularly, in terms of its mass m, amplitude (ρ) and time (τ) of vibration; from Simon's value, $1{,}865.10^7$ (Wied. Ann. 69. p. 611, 1899) of the ratio of the charge of the electron to m, he derives $5{\cdot}19.10^{-4}$ for the value of the ratio of m to the mass of the hydrogen atom. The energy (K) of the electrons in a gramme-equivalent is therefore $2\pi^2\rho^2 n.5{\cdot}19.10^{-4}/T^2$, n being the number of electrons in an atom. K must be less than the total energy of the gramme-equivalent, and is equal to $a.1{\cdot}26.10^8\,T$, where a is less than unity and T is the absolute temperature. Thus ρ is found to be $10^{-8}\sqrt{a/n}$ approximately.

W. E. T.

839. *Energy Emitted and Absorbed by a Vibrating Ion.* **M. Planck.** (Archives Néerlandaises, 5. pp. 164–174, 1900.)—The vibrating negatively charged ion or electron is supposed to be the seat of radiation and absorption, absorption causing an increase of its energy of vibration and radiation a diminution of the same. A single negative ion combined with a stationary positive ion to form a molecule is supposed to be situated in vacuo, and owing to the rapid vibration of the negative ion, the molecule constitutes an electric dipole of rapidly changing moment. The expression for the energy emitted by such a dipole is first of all deduced without assuming any particular path for the negative ion, and also an expression for the energy absorbed from an incident train of waves.

These expressions are—

Energy emitted in time $dt = \frac{2\,dt}{3\,V^3}(\ddot{m}_x^2 + \ddot{m}_y^2 + \ddot{m}_z^2)$, where m is the moment of the dipole and V the velocity of light.

Energy absorbed in time $dt = (F_x \dot{m}_x + F_y \dot{m}_y + F_x \dot{m}_z)\,dt$ where F_x, F_y, F_z are the components of the electric force of the incident waves at the ion.

These expressions only hold when dt is great compared with the period of vibration.

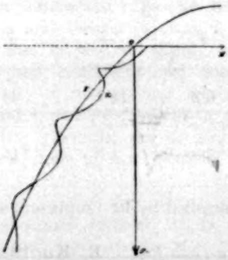
Assuming the path of the ion to be approximately elliptical, these expressions give us the equations of motion for such an ion. They are—

$$Km_x + L\ddot{m}_x + \frac{2K}{3V^3L}\dot{m}_x = F_x,$$

and similar equations for y and z, K and L being constants. J. B. H.

840. *Electron Theory of Metals.* **P. Drude.** (Ann. d. Physik, 3. 3. pp. 369–402, Nov., 1900.)—In this second part of his work [see Abstract No. 1276 (1900)], the author deals with the calculation of the electric and thermal transverse effects from data supplied by the electron theory. The theory is best tested by determining for different metals the four transverse effects, as well as the electric and thermal conductivities. When that is done, the mutual electric relations of the metals, more especially the Peltier effect and the thermo-electric force, must result quantitatively. The Thomson effect should also be useful, at all events as regards sign. The reverse process, which consists in determining the thermal conductivity from the four transverse effects and the electric conductivity, is even preferable. The order of magnitude of the Thomson effect in bismuth gives very nearly the same ratio for the conductivity of the positive electrons to the total conductivity as the value obtained from the four transverse effects, being 0·029. A further proof lies in the connection between the Hall effect and the thermo-electric force. When the metals are arranged in the two series there is a well-marked general parallelism, especially at both ends. The middle members do not agree, and cobalt forms a striking exception, standing near antimony in the Hall-effect series, and near bismuth in the thermo-electric series. The author is not inclined to accept the supposed existence of more than two species of conducting electrons until further experimental material is available. In discussing the optical qualities of gold and copper, the assumption of conducting electrons alone does not seem sufficient, and indeed the author inclines to the assumption of non-conducting electrons in all cases. For if none such existed, his theory would demand the disappearance of the thermo-magnetic transverse temperature effect. The constants of such non-conducting electrons, which are probably fixed in position, can be determined only when the constants of the moving (conducting) electrons are known. Some general conclusions may, however, already be deduced from the optical qualities of metals, and this the author intends to do in the next part of his dissertation. E. E. F.

841. *Motion of an Electrified Particle.* **E. Riecke.** (Phys. Zeitschr. 2. pp. 217–218, Jan. 5, 1901.)—The author has investigated the case where an electrified particle or ion moves in a magnetic field upon which an electric field is superimposed, both fields being uniform. The result of analysis shows that the particle moves along a cycloidal curve. In the diagram, OF is the direction of the electric force, and ON is normal to OF and to the magnetic force. The projection of the path of the particle upon the plane FON is the curve π. The axis of the cycloid is a parabola, the generating curve is no circle but an ellipse, and the arcs of the cycloid expand during the motion. These results have an important bearing upon the phenomena in the vicinity of the kathode, the changes in luminous layers under magnetic influence, and the theory of the aurora. E. E. F.



842. *Measurement of Atmospheric Electricity.* **F. L. Tufts.** (Amer. Phys. Soc., Bull. 1. pp. 37–39, 1900.)—Experiments were undertaken at Columbia University to study the behaviour of different electrodes in the measurement of atmospheric potential. The electrodes were a flame, a water dropper and a metal point, and were fixed 10 metres from the ground. The potential was measured by the discharge of a condenser of 0·0001 microfarad capacity through a d'Arsonval galvanometer. This condenser assumed the potential of the electrode within one second, and potentials ranging from 5 volts to a few thousand volts could be measured. The potentials assumed by the flame and by the water dropper were usually about the same; that by the point was always much lower. The variations of potential were very rapid; on one occasion a charge from plus 300 volts to minus 280 volts occurred in half a minute. G. H. B.

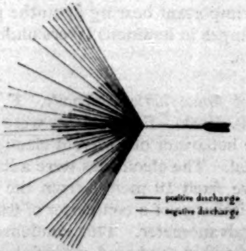
DISCHARGE AND OSCILLATIONS.

843. *Brush-discharge Tones.* **K. Przibram.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 902–904, 1900.)—This is a preliminary note describing experiments made to determine the periodicity of intermittance of brush discharges. According to Beccarias the negative brush-discharge in free air gives a higher tone than the positive. Quantitative experiments are difficult, especially when the medium is changed to various gases. Moreover, since the brush discharge is not of great brilliance, the strobo-photographic method is not easy of application. The author therefore replaces the rotating mirror by a rotating photographic film, and directs the discharge from the electrodes against the films themselves. To determine the velocity of rotation of the film, the light from an arc-lamp is directed upon it through a slit which is closed intermittently at known short intervals by a tuning-fork. After the principal discharge there follows a succession of weaker brushes; these are more pronounced on the kathode than upon the anode, and of greater duration on the kathode. The results for Air and CO_2 are shown in the following table:

	Time between successive discharges.		Total duration of discharges.	
	+	−	+	−
Air	6·8	1·1	33	42
CO_2	3·9	1·3	15	60

The figures when multiplied by 10^{-4} represent seconds. R. A.

844. *Discharge from a Tesla Pole.* **E. Knoblauch.** (Phys. Zeitschr. 2. pp. 165–166, 1900.)—High-frequency currents discharged from a fine point produce in a metallic plate mounted in its neighbourhood a positive charge, but they produce a negative charge when the distance between the point and the plate exceeds a certain value. This remarkable circumstance is due to the issue of positive brush discharges, which penetrate only to a short distance. The distribution of the two types of discharges is shown in the diagram.



An analogous phenomenon is presented by Lichtenberg's figures.

E. E. F.

845. *Ionisation and Unipolar Discharge.* **J. Stark.** (Ann. d. Physik, 4. 2. pp. 402–415, Feb., 1901.)—A theoretical discussion of ionisation, its causes and limits, stationary ionisation and stationary current, unipolar ionisation, effect of temperature, and unipolar discharge from glowing bodies. For a preliminary paper on the same subject, see Abstract No. 92 (1901.)

D. E. J.

846. *Telephonic Arc-Lamps and Wireless Telegraphy.* **H. T. Simon.** (Phys. Zeitschr. 2. pp. 253–258, Jan. 26, 1901.)—Reference is made to the author's earlier observations [Abstract No. 526 (1898)] on the sound produced by an arc-lamp whose current undergoes periodic variations, and on the inverse influence produced by sound waves, impinging on the arc, upon the strength of the current. On September 8, 1900, the author showed the Physische Verein that the effect could be made extremely loud. Since then he has applied the idea to wireless telegraphy. The telephonic effect is obtained by superposing on a constant direct lighting current, by means of induction, a variable microphone current; and probably the sound is due to variations in the heat produced, and in any case the tendency is to have a greater effect ($\propto i.\ di.\ r.$) the more powerful the main current and the greater the amplitudes of the microphonic current. A Schuckert projection lamp, 16–20 amperes, with differential regulator, was used, and a "1,000-kilom." microphone by Mix and Genest (5 ohms, 2 to 4 volts). A mathematical investigation of the subject is given, from which the most advantageous dimensions and conditions are computed. The wireless arrangement consists of (1) a microphone circuit and a lamp circuit interacting by induction, and a parabolic mirror to produce a parallel beam of light; and (2) a receiving parabolic mirror with a selenium cell at its focus, and a battery and telephone in the circuit of this cell. Reference is made to Duddell's work. A. D.

847. *Velocity of Ions drawn from a Flame.* **C. D. Child.** (Phys. Rev. 12. pp. 65–83, Feb., 1901.)—Two large parallel tin plates were charged to a known potential difference by means of a water battery; a flame was placed close to one plate and the fall of potential in the space between the plates measured by an electrometer connected to a water dropper. The current, when large, was measured by a galvanometer, and, when small, by noting the rate at which a condenser became charged. When the distance from the flame to the distant plate was 6 cm. and the total p.d. 98·5 volts, the p.d. between the flame and the air space was 7 volts at 1 cm. and 76 volts at 5 cm. from the flame, the corresponding values of the electric intensity (deduced from the curve of fall of potential) being 9·8 and 22 volts per cm., the current density was $0{\cdot}89 \times 10^{-11}$ amperes when the flame was positively charged and the current was carried entirely by positive ions. Substituting these values in the equation given by J. J. Thomson, the velocity of the positive ions is calculated to be 2·08 cm. per sec. for 1 volt per cm.

A simplification of Thomson's method is given in which it is not necessary to measure the fall of potential at points between the plates, but only the current between them; this is based on the supposition that the number of ions in the flame is large compared to the number withdrawn by the current, and that the rate of change of potential in the immediate neighbourhood of the flame is negligible. It leads to the equation $k = 32\pi \times 10^{11} \frac{ib^3}{V_b}$, where k is the velocity, i the current density, b the distance and V_b the p.d. between the flame and the distant plate. Using this equation it was found that the values for the velocity of both the positive and negative ions decreased as the distance *b* was increased, and it is suggested that this is due to a gradual decrease in the velocity of the ions after leaving the flame. T. M. L.

848. *Velocities of Ions in the Electric Wind.* **A. P. Chattock, W. E. Walker** and **E. H. Dixon.** (Phil. Mag. 1. pp. 79-98, Jan., 1901.)—This paper forms a continuation of a former one by one of the authors [Abstract No. 104 (1900)], in which the velocities of the ions in the electric wind in air were calculated. The experiments have here been extended to hydrogen, carbon dioxide, oxygen and turpentine. The conclusions are as follows:—

1. The values of V for point-discharge in gases are in approximate agreement with those obtained for the same gases when ionised by Röntgen rays.

2. In non-conducting liquids, V appears to be of the same order of magnitude as in ordinary electrolytes.

3. In hydrogen for negative discharge only, and probably in turpentine for both kinds of discharge, a considerable "back-discharge" of ions seems to occur from the brass or platinum ring towards the point.

4. The amount by which this back-discharge lowers the wind-pressures in the case of hydrogen is closely proportional to the strength of current from the point. This is proved by the constancy of Z_0 in each group of observations.

5. Negative ions in constant fields travel at very varying rates in hydrogen; the same being true of oxygen and air, but to a much less extent. These variations are real, and not attributable to errors of observation or other accidents. Positive ions are not affected in this respect to anything like the same extent, if at all.

6. To account for this, it is suggested that a certain number of the negative ions may owe their origin to occluded gases in the point; that this number may be variable owing to changes in the accessibility of the occluded gases and other causes; and that the specific velocity of the positive ions may be constant owing to their being formed exclusively of the gas outside the point.

A very sensitive manometer was used in the measurements. It consists of an ordinary oil and water differential manometer mounted on a frame, which can be inclined by means of a micrometer screw. Instead of reading the displacement in the narrow tube of the oil-water interface, the interface is kept stationary in the tube by tilting the frame, and the reading of the micrometer screw gives a measure of the pressure. J. B. H.

849. *Leakage of Electricity through Dust-free Air.* **C. T. R. Wilson.** (Cambridge Phil. Soc., Proc. 11. p. 32, Jan. 30, 1901.)—Elster and Geitel [Abstract No. 2023 (1900)] have shown that an electrified body gradually loses its charge when freely exposed in the open air or in a room, and they conclude from their experiments that free ions exist in the atmosphere. In the present experiments the author proves that ionisation can be detected in a small closed vessel containing dust-free air not exposed to any known ionising agents. The rate of leakage is the same in filtered air whether the apparatus be filled and used in the laboratory or in the country; it is the same for positive as for negative charges, and the same in the dark as in diffuse daylight. To a first approximation the rate of leakage is proportional

to the pressure, being at a pressure of 43 mm. about one-fourteenth of that at atmospheric pressure. Taking the value found by J. J. Thomson for the charge carried by each ion, $6{\cdot}5 \times 10^{-10}$ E.U., the experiments indicate that 20 ions of either sign are produced per second in each c.c. of air at atmospheric pressure. W. C. H.

850. *Rapid Variations in Current through Direct-Current Arcs.* **W. Duddell.** (Inst. Elect. Engin., Journ. 30. pp. 232–267; Discussion, pp. 267–283, Feb., 1901.)—This paper is divided into two parts. Part I. deals with effects produced by variations in the current, these variations being generally much less than 10 per cent. of the mean current. When the arc is between solid carbons and the current is suddenly increased, the p.d. and current increase together for less than about $\frac{1}{5000}$th of a second; at the end of this very short time the p.d. decreases with an increase of current in the ordinary way. If the current through the arc varies by as little as 8 per cent. from the mean, and if the frequency of these superimposed variations is even as high as 4,300 ∿ per second, a variation in the light emitted by both the + crater and the vapour column can be detected. A rapid periodic variation of the order of one part in 10,000 from the mean current will alter the vapour column of the arc sufficiently to produce sound waves, as there is probably a definite cross section of the vapour column corresponding to each value of the current. A variation of current of one part in 100 will produce sound waves even at frequencies as high as 30,000 ∿ per second. The arc is affected by such small changes of outside conditions as sound waves produce, and can be used both as a telephone transmitter or receiver.

Part II. deals with the variations produced in the current by the arc itself. When the arc hums it rotates and the p.d. current and light emitted vary periodically, the frequency of these variations being the same as that of the rotation of the arc as a whole, and of the pitch of the humming sound. In the hissing arc the p.d., current and light emitted vary very irregularly, the larger and slower variations corresponding with a rotation of the arc as a whole, and the smaller and more rapid to the hissing proper, *i.e.*, the oxygen of the air obtaining access to the crater surface as demonstrated by Mrs. Ayrton. A very short arc, so short that practically no light can get out from between the carbons, sometimes produces a shrill whistling sound accompanied by a small green tongue of flame. This is probably due to the periodical short-circuiting and relighting of the arc, the short-circuit being caused by a bad contact such as a loose piece of carbon. Under certain conditions the direct-current solid carbon arc will emit a musical note when shunted by a self-induction in series with a condenser. When emitting the musical note, the direct-current arc transforms direct-current energy into alternate-current energy, the frequency of the latter being determined by the self-induction, capacity, and effective resistance of the oscillating circuit. The pitch of the note emitted may be used as a means of comparing self-inductions and capacities. If a direct-current arc be shunted with a condenser of several microfarads capacity, the arc will generally be extinguished if the electrodes are of metal, and not if they are of cored carbon, the resistance in series with the arc being non-inductive. If the resistance in series with the arc be highly inductive, then, when the metal arc is extinguished by shunting it with a condenser, a violent rise in p.d. occurs between the terminals of the arc. The rise in p.d. that occurs when an inductive circuit is broken by means of a switch, the contacts of which are shunted by a condenser, is much higher if these contacts are of metal than if they are of cored carbons, owing to the condenser extinguishing the metal arc formed at the contacts more suddenly than the arc formed when carbon contacts are separated. In an appendix the author mentions that he has obtained a spark of from two and a half to three times the usual length from an induction coil by arranging a contact breaker which applies the condenser to the spark-gap a certain time after the separation of the contacts.

Discussion.—**Ayrton** pointed out that if an arc supplied by accumulators is inserted in any given alternate-current circuit, so that the arc is common to the two circuits, the current in the alternating circuit will be larger than it was before the arc was inserted, other conditions being the same. **O'Gorman** thought cases of damage to concentric cables from the sudden interruptions of the arc between metal contacts of the switch likely to be very rare. **Marchant,** in reference to the introduction of an iron-wire core into the self-induction used to produce the musical arc, pointed out that the eddy current loss in iron wires is many thousand times greater than that in copper, in spite of the relatively great conductivity of the latter. With No. 28 soft iron wires with an induction density of about 15,000 lines per square cm. and frequency 1,000, the eddy current loss is double that due to hysteresis.

E. C. R.

851. *Luminescence and Stratification in Gases carrying Electric Currents.* **J. Stark.** (Phys. Zeitschr. 2. pp. 233–238, Jan. 19, 1901.)—A continuation of previous papers [see Abstracts Nos. 2202, 2203 (1900), and Nos. 98 and 387 (1901)]. The dispersal of kathode rays, ionisation, length of free path, and stratification are discussed with especial reference to the experiments and theories of Goldstein, Lenard, Hittorf, and Thomson.

D. E. J.

852. *Striated Discharge.* **E. Riecke.** (Phys. Zeitschr. 2. pp. 227–229, Jan. 12, 1901.)—This paper contains a synopsis of a mathematical investigation of the motion of charged particles in an electric field, with the object of explaining the striæ in the discharge in a Geissler tube. [In this connection see also the papers by J. H. Jeans, Abstract No. 1069 (1900), and by G. W. Walker, Abstract No. 1830 (1900).] The author assumes that the potential of the mutual force between two of these charged ions is only $1/r$ for large values of the distance r, and that for small values of r the potential and its differentials are much greater than according to that law. Assuming the motion of all the particles to be in the direction of the electric force, the force on a particle is given by—

$$X = -P\epsilon(1 - ku^2)\frac{d\eta}{dx} + Qk\epsilon\eta\frac{du^2}{dx} - Rk\epsilon\eta\frac{d^3u^2}{dx^3}$$

where u is the velocity of the particle, η is the volume electric density at the point x, y, z, where the particle is situated, k is the square of the reciprocal of the velocity of light, and P, Q, R are constants which depend on the potential function. For the steady state the current $i = \eta u$. The equation of motion for the particle follows, and assuming the velocity $u = u_0 + u'$ where u' is small compared with u_0 the equation for u' is integrated and the solution is found to be partly periodic. The velocity of the particle thus contains a term which is a periodic function of x. If the particle is supposed to be moving in a frictionless medium the solution is aperiodic. The wave-length of the periodic function is much smaller for the positive ions than for the negative, and herein lies the possibility of solving the problem of the electric double current in a Geissler tube, at least approximately. Assume that the total quantity of positive charge on ions in the tube is approximately equal to the total negative charge on ions, then, if certain inequalities exist between the controlling constants, a periodic interchange of positive and negative charges must take place in the tube, as observed in the striæ. J. B. H.

853. *Temperatures in Geissler Tubes.* **K. Kerkhof.** (Ann. d. Physik, 4. 2. pp. 327–344, Feb., 1901.)—G. Wiedemann found (by means of a thermo-element applied outside the capillary tube) that in tubes having the same internal diameter, but different external diameters, the discharges of an induction machine produced approximately equal amounts of heat in equal times. The object of the present investigation is to test, by means of the bolometer, the deduction from Wiedemann's law that the temperatures of gases in tubes of different diameters are inversely proportional to the cross sections, the gases examined being carbon dioxide, oxygen, air, and hydrogen. The experiments do not support the conclusion. Wiedemann's law can be brought into harmony with the results of experimental investigation of the actual temperatures of gases in tubes of various cross-sections by assuming that during the discharge heat is given off to the glass and to the surrounding atmosphere. A theoretical discussion shows that when the thickness of the glass wall is constant, the temperature, instead of being proportional to the inverse square of the radius, is at most inversely proportional to the radius; also that, in accordance with the heat conductivities of hydrogen and air, the differences in temperature for different cross-sections should be greater for air than for hydrogen.

In view of the general opinion that the change of the band-spectrum to the line-spectrum produced by using a spark-gap is determined by a rise in temperature, it seemed desirable to examine the changes in temperature produced on inserting a spark-gap. It was found that the insertion of a large spark-gap (2–3 cm.) always gave increased temperatures, and that these increases were more important at low temperatures. The insertion of small spark-gaps lowered the temperature, the probable explanation being that they do not alter the course of the discharge, inasmuch as the Geissler tube requires a higher potential than is necessary for springing across the small gap. Owing to the presence of the latter, however, a part of the energy is lost in the form of heat; thus there is a lowering of the temperature, and this lowering becomes more marked as the length of the spark-gap is increased, and the cross-section of the tube is diminished. But when the length of the spark-gap is so far increased that the difference of potential required to cross it becomes important, then the whole course of the discharge process, as E. Wiedemann has shown, becomes modified; the quantities of electricity which pass through the Geissler tube become greater, and there is a rise of temperature. It may be assumed that when the spark-gap is such as to give the maximum lowering of temperature, the difference of potential required to cross it is the same as that required for the tube; its length must therefore depend upon the pressure.

Schuster and Hemsalech [see Abstract No. 1066 (1900)] found that when a coil of sufficient self-induction was introduced into the spark-circuit, the air-lines disappeared; and this was explained as being due to a lowering of temperature. The author finds that when the discharge takes place in a Geissler tube (instead of between metallic poles in air) the introduction of a special coil causes a rise of temperature at the positive end and a lowering of temperature in the neighbourhood of the kathode. D. E. J.

854. *Hertzian Resonators.* **A. Turpain.** (Archives Néerlandaises, 5. pp. 152–163, 1900.)—By enclosing the wire of a Hertzian resonator in a glass tube along its whole length except at the spark-gap, and exhausting the air from the tube, the condition of the wire with respect to electric pressure is shown by a glow round the wire at the points where the pressure is greatest.

The author has experimented with various modifications of this resonator :—resonators with one or more gaps in different relative positions, resonators with one gap inside the exhausted tube while the other is outside, and resonators with two adjustable gaps.

The experiments lead to the conclusion that the resonator with one gap possesses two nodes, one at each side of the gap, and one ventral segment diametrically opposite to the gap. The pressure at the nodes is greatest when the gap is too great for a spark to pass.

The effect of a small second gap is to reduce the pressure at the two ends of the first gap so long as a spark passes at the second gap, but when the latter is widened so that no spark passes it then resonance ceases. J. B. H.

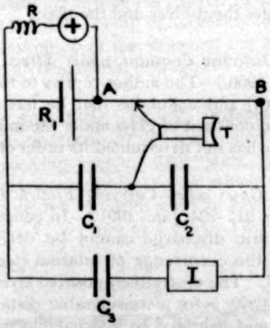
855. *Coherers.* **C. Jensen.** (Phys. Zeitschr. 2. pp. 211–213, Jan. 5, 1901.) —Röntgen rays often exert an apparent influence upon the resistance of coherers. The author mentions that when he introduced a Röntgen tube into the secondary circuit of an induction coil a Kohl detector for wireless telegraphy showed an immediate response. The response occurred even after taking all kinds of precautions against stray sparks, but it was entirely obviated by enclosing the Röntgen-ray tube in a box with an aluminium window, through which X-rays could freely penetrate. It is therefore clear that X-rays alone do not produce the effect described. The real cause of the effect upon the coherer was, after much investigation, found to lie in the appearance of "gliding sparks" inside the Röntgen tubes themselves. These gliding sparks play about the metallic conductors within the tubes, and appear to glide to and fro along them. That these sparks are the true cause of the phenomenon is made probable by the fact that the appearance or non-appearance of the response depends upon the position of the point at which the sparks appear with respect to the coherer. Preliminary experiments with Becquerel rays show that they have no influence upon coherers.

E. E. F.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

856. *Electrical Resistances of Pure Metals.* **E. van Aubel.** (Archives Néerlandaises, 5. pp. 49–55, 1900.)—This paper is an examination of Dewar and Fleming's determination of the electrical resistances of tin, cadmium, and nickel at different temperatures. The resistance of tin in microhms per cub. centimetre was found in 1892 to be 9·609 at 0·8° C., while in 1893 it was 13·100 at 1·0° C., the tin wire being prepared differently in the two cases. The resistance of cadmium was found to be 10·023, with a temperature coefficient between 0° and 100° C. of 0·00419. Benoit, however, found a resistance of 6·85, with a temperature coefficient of 0·00444. For nickel, prepared from nickel-carbonyl, Dewar and Fleming found in 1892 and 1893 resistances of 12·350 and 12·402 at 1·2° C., the temperature coefficients, however, varied from 0·0049 to 0·0298 ; in 1900 Fleming found for nickel prepared electrolytically, a resistance of 6·935 at 0° C. with a temperature coefficient varying from 0·0058 to 0·2074. The author considers these results so divergent as to render doubtful Dewar and Fleming's conclusions, that the resistance of pure metals vanishes at absolute zero of temperature. He also considers it unadvisable to make measurements extending over a large range of temperature on other than straight wires. G. H. B.

857. *Resistance of Lead Accumulators.* **F. Dolezalek** and **R. Gahl.** (Zeitschr. Elektrochem. 7. pp. 429–433, Jan. 24; and 437–441, Jan. 31, 1901.)—After a description of some previous observations, the authors describe a method for the measurement of cell resistance. It is essentially a Kohlrausch alternating current and telephone method, but involving the use of condensers. The diagram shows the arrangement of the apparatus. An induction coil, I, with fine wire primary connected to the 110-volt circuit has in its secondary circuit an aluminium cell, C_3, which acts as a condenser. Two other condensers, C_1 and C_2, each made of 50 sheets of tin foil, 4 square decimetres in area, insulated with paraffin paper and mounted between boards that may be pressed together with a wooden screw, are used. The bridge, AB, is of 3 mm. thick rheotan wire of 1 m. length. At the ends A and B are mercury cups.



A telephone, T, with short, thick windings, is arranged as shown with a contact variable along the bridge wire. The cell, R_1, is discharged through glow-lamps, R, and has in its circuit an ammeter. It is also provided with a voltmeter (not shown) at its terminals. The wire, AB, is calibrated by using known resistances placed at R_1 instead of the cell. With this apparatus many measurements have been made, and the results are given in the form of curves showing the dependence of the resistance on the state of charge. Measurements have also been made to separate the resistance of the positive plate from the negative plate by using an auxiliary electrode of lead peroxide. These show that the variation of the resistance of the positive plate is relatively of small importance. The influence of the charges of concentration of the electrolyte, due to diffusion when the cell is not in use, are discussed. W. W. H. G.

858. *Electric Convection.* **V. Crémieu.** (Soc. Franç. Phys., Bull. 156. pp. 2–3, 1901.)—The reciprocal of the Rowland effect would be an inductive ponderomotive force acting on a body bearing a charge and placed near an electromagnetic solenoid in which there was a variation of flux $d\phi/dt$. Crémieu has been unable to find any such effect. He has also tried the Rowland phenomenon with more powerful apparatus, and concludes that

there is no magnetic effect of convection, but that there are some deviations due to a phenomenon of conduction in the fixed sectors of his rotating apparatus. [See also Abstract No. 144 (1901).] A. D.

859. *Oil in Mica.* **T. O. Moloney.** (Elect. Rev. N.Y. 38. p. 107, Jan. 19, 1901.)—The puncture resistance of mica was found to be reduced by one-half its value by lightly coating the surface with paraffin oil. M. O'G.

860. *Dielectric Cohesion in Gases.* **E. Bouty.** (Soc. Franç. Phys., Bull. 158. pp. 5–6; Discussion, pp. 6–7, 1901.)—A gas, within glass, in an electrostatic field acts as a perfect dielectric up to a certain critical value of the field. Thereafter it yields and acts as if it were a metal. Dry steam is a perfect insulator. The critical value of the field is, for pressures above a few mm. of mercury, a linear function of the pressure: at progressively smaller pressures it passes through a minimum and then increases, nearly inversely as the square of the pressure, down to about $\frac{1}{50}$ mm. The strength of field requisite for sparking is also a linear function of the pressure, together with a term which depends on the electrodes themselves and the glass. A. D.

861. *Variation of Dielectric Constant under Stress.* **G. Ercolini.** (N. Cimento, 12. pp. 77–90, 1900.)—The author replies to the criticism of Corbino [Abstract No. 134 (1900)] and maintains that he has clearly established an increase of the dielectric constant of glass under the influence of tension. He admits, however, that he has not determined its order of magnitude. E. E. F.

862. *Conductivity of Gases when Carrying Electric Discharges.* **J. Stark.** (Ann. d. Physik, 4. 1. pp. 215–224, Jan., 1901.)—In general the conductivity of a gas carrying an electric discharge cannot be determined by the usual methods on account of the occurrence of internal electromotive forces [see Abstract No. 387 (1901)]. The unstratified positive layer is an exception. In it the transverse conductivity is for a considerable distance constant; the gas is in an uniform state and exhibits no internal electromotive forces. The specific conductivity is $\lambda = i.l/q.e$, where i is the current and e the potential difference between two layers of cross-section q and at a distance l apart. The author calculates its values for pressures of 1–7 mm. from the observations of A. Herz (Wied. Ann. 54. p. 254, 1895). The results obtained are as follows: I. *Variation of Current.*—For small current-densities the conductivity is proportional to the current-density; for larger current-densities the conductivity increases more rapidly than the current. II. *Variation of the Cross-Section.*—The effect of current-density on conductivity is also shown by varying the cross-section while the current remains constant: in this case also the conductivity increases with the current-density. But for equal current-densities the conductivity is smaller for small cross-sections than for large ones. III. *Effect of Pressure on Conductivity.*—The conductivity increases rapidly when the pressure diminishes.

The author takes as normal or mean value of the variables concerned a current of 1 milliampere, a pressure of 4 mm., and a cross-section of 2 sq. cm., and for these values gives the conductivity of nitrogen as $11{\cdot}28 \times 10^{-6}$ and of hydrogen as $17{\cdot}29 \times 10^{-6}$. D. E. J.

863. *Thermo-electric Behaviour of Metallic Oxides and Sulphides.* **E. van Aubel.** (Ann. d. Physik, 4. 2. pp. 416–419, Feb., 1901.)—A. Abt [see Abstract

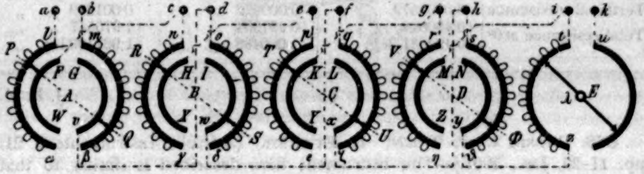
No. 1680 (1900)] has investigated the thermo-electric behaviour of certain metallic compounds. He places them in a series beginning with chalcopyrite (negative) and ending with pyrite (positive), and states that the members of this series follow approximately the laws which represent the behaviour of the corresponding thermo-electric series of metals. Thus, for example—

Pyrolusite | Carbon + Carbon | Pyrite = Pyrolusite | Pyrite
815·2 + 615·6 = 930·8 (933·2 observed).

The author has tested the accuracy of this statement by examining and comparing other data given by Abt, and finds that it is not justified. D. E. J.

864. *Conductivity for Heat and Electricity, Heat-Capacity, and Thermoelectric Power of Certain Metals.* **W. Jaeger** and **H. Diesselhorst.** (Phys. Tech. Reichsanstalt, Wiss. Abh. 3. pp. 269–424, 1900.)—This is the complete memoir corresponding to Abstract No. 137 (1900). It contains elaborate mathematical discussions of the sources of error, and gives full details of the precautions that must be taken in the experiments, and of the corrections that must be applied in the calculations. The numbers given in the former paper have been revised, the chief alterations being in augmentation of the values of λ/κ at 100° C. with slight diminution of the values of κ at 100° C.; the results for manganin (84Cu, 12Mn, 4Ni) are also now given. R. E. B.

865. *New Form of Slide-Wire.* **M. T. Edelmann.** (Elektrotechn. Zeitschr. 21. p. 1067, Dec. 20, 1900.)—The arrangement will be easily understood from the accompanying sketch. The "wire" consists of a series of coils connected to circular contact-blocks over which a contact-arm may be made to move. Each of the eighteen coils in the set A has a resistance of 1,000 ohms; in B, 100; C, 10; and D, 1 ohm. The 10 coils at E have each a resistance 0·1 ohm. The contact-arms which move over A, B, C, and D are each furnished with two diametrically opposite contacts insulated from each other, while the arm at E is a metallic arm bridging across the semicircular series of contacts on the left and the semicircular contact-ring on the right: *a* and *b* correspond to the ends of the "slide-wire," while *k* is the point of division. A. H.



866. *Errors in Magnetic Measurements due to Skin of Oxide.* **H. Kamps.** (Elektrotechn. Zeitschr. 22. pp. 75–79, Jan. 24, 1901.)—On account of the skin of oxide which forms on the surface of iron stampings, the actual cross-section of iron is somewhat uncertain. The present paper contains an account of experiments undertaken with a view to determining the amount of error incurred in magnetic measurements due to this cause. The author determined the apparent induction on the supposition that the entire cross-section consisted of iron, and then found the true induction by dissolving off the skin of oxide. The results indicate that the apparent differs from the true induction by an amount ranging from 6·7 per cent. in the case of stampings 0·75 mm. thick to 18 per cent. for stampings 0·375 mm. thick. The thickness of the double skin of oxide deduced from these measurements is about 0·05 mm. The author further discusses the errors introduced into measurements of the hysteresis loss when (*a*) the field intensity and (*b*) the induction is the same in two samples with and without a skin of oxide respectively.

A. H.

867. *Mercury Standard for the Ohm.* **W. Jaeger** and **K. Kahle.** (Zeitschr. Instrumentenk. 21. pp. 1–10, Jan., 1901. From the Phys. Tech. Reichsanstalt, Wiss. Abh. 3. p. 95–153, 1900.)—In a former paper (Zeitschr. Instrumentenk. 16. p. 134, 1896) an account is given of the formation of two mercury columns for the standard of resistance in the Reichsanstalt. It was thought advisable to use a larger number of mercury columns in the Definition of the practical unit of resistance and three others were accordingly made. The present paper describes the standardising of these three. One had a section of about 0·5 sq. mm. and a resistance of about 2 ohms; the second a section of 1·3 sq. mm. and 0·5 ohms resistance; and the third, like the old ones, a resistance of about 1 ohm and a section of 0·75 sq. mm. The results are given in the following table:—

Number of Tube.	No. 106.	No. 114.	No. 131.
Length at 0°	654·954 mm.	810·947 mm.	1009·627 mm.
Hg-contents at 0° ...	11·20122 gm.	8·43914 gm.	6·60451 gm.
Sectional area (about)	1·258 mm².	0·766 mm².	0·481 mm².
Calibration factor ...	1·000169	1·000021	1·000168
Resistance at 0°	0·4898850 int. ohms	0·996692 int. ohms	1·974328 int. ohms
Terminal resistance	0·0007579 „ „	0·000972 „ „	0·001219 „ „
Total resistance at 0°	0·490642$_9$ „ „	0·997664 „ „	1·975547 „ „
	0·492031$_5$ leg. „	1·000488 leg. „	1·981139 leg. „

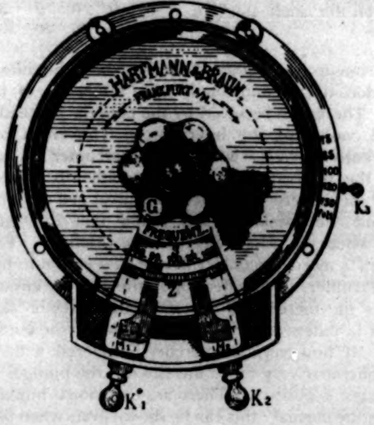
J. B. H.

868. *Periodic Curve Tracer.* **R. Franke.** (Zeitschr. Instrumentenk. 21. pp. 11–20, Jan., 1901.)—The instrument here described is similar to that formerly described by the same author [see Abstract No. 186 (1900)]. The alterations introduced here consist only of improvements in the mechanical details and in the arrangement of the parts to ensure that the axis of rotation of the brushes shall coincide with the axis of rotation of the commutator. For this purpose the brush-holder is mounted on a ball-bearing on the commutator itself instead of on the framework, and it is kept from rotating by a projecting arm carried by the frame, which can be slowly rotated by hand so as to make the brushes close the circuit at all the different phases of the alternating current.

J. B. H.

869. *Measurement of Frequency.* **R. Kempf-Hartmann.** (Elektrotechn. Zeitschr. 22. pp. 9–15, Jan. 3, 1901.)—After briefly reviewing the various methods which have from time to time been used for frequency measurements, the author explains the main principle underlying the construction of his own instruments. This consists essentially in using a series of steel

tongues capable of vibration when excited by an electromagnet traversed by the alternating current. The amplitude of vibration is very considerable, so that the vibration is clearly visible. The construction of this type of instrument will be readily understood by reference to the accompanying figure. Rigidly clamped to the periphery of a movable circular frame is a set of steel tongues, the vibration frequencies of which range from 79 to 110. Any one of these tongues may, by means of the milled head G, be brought within the range of action of an electromagnet which is excited by the alternating current. This electromagnet consists of two parts, M_1 and M_2, which may be displaced relatively to each other by means of the handles K_1 and K_2. When it is desired merely to determine the frequency, M_1 and M_2 are brought together, and the compound pole-piece thus formed is of sufficient width to act simultaneously on two neighbouring tongues. The milled head G is then turned until a pair of tongues is reached whose vibration amplitudes exceed those of any other pair. By comparing the relative amplitudes of the strongly vibrating tongues, fractions of a period may be estimated. If it is now desired to study fluctuations of frequency, the component parts M_1 and M_2 of the magnet are separated, and the sound ceases. But if the frequency either falls to that corresponding to the tongue opposite M_1, or rises to that corresponding to the tongue opposite M_2, the observer is immediately warned of this fact by the note emitted by the corresponding tongue. The concluding portion of the paper describes the application of this principle to the determination of the slip of induction motors. A. H.



870. *Wehnelt Interrupter.* **A. Lampa.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 891–901, 1900.)—The Wehnelt interrupter is less efficient when the smaller electrode is negative than when it is positive. Simon attributes this to a secondary action resulting from the occlusion of hydrogen by the platinum. Wehnelt and Spiesz thought it might be due to the difference in the character of the sparks corresponding to the two directions of the current. The author investigates the question by experiments made with a coherer circuit containing a galvanometer. The apparatus is not described, but it appears that the coherer is used as a quantitative detector for the waves, the throw of the galvanometer being assumed proportional to the intensity, or some other quality, of the spark. The result arrived at is that the effect upon the coherer under continued sparking at the interrupter is very pronounced when the smaller electrode is negative, but that the effect is very small when the smaller electrode is positive. The length of the smaller electrode was next varied by increments from 18·2 mm. to 0·1 mm. So far as these observations go, it appears that the effect on the coherer is the same for both these lengths, but that it is greater for lengths between those values. As against the occlusion theory, the following table shows the galvanometer throws corresponding to the electrodes of different metals :—

		Pt	Cu	Ir	Fe	Ag	Pd	Au	Al
Deflections when the small electrode is	positive	6	2	6	2	5	5	1	5
	negative	20	16	26	20	18	18	12	19

From these experiments the author concludes that the difference produced by commutation does not depend simply upon the nature of the metal of the small electrode. The waves received by the coherer proceed of course from the whole circuit containing the interrupter. The effect produced at the coherer is, apparently, greatest when the interrupter is working quietly, and least when the interrupter is working violently. Using a Geissler tube in place of the coherer as a detector, arranged as in the experiments of Borgmann and Petrowski, it was found that the effect upon the tube is greatest when the small electrode is positive. Further tests are described in which a mercury contact key, with a platinum plunger, replaces the Wehnelt interrupter. The effect upon the coherer circuit in this case is the same whether the mercury is covered with water or alcohol, or is left uncovered, and it is independent of the direction of the current through the mercury contact. If, however, the mercury is covered with dilute acid, the effect upon the coherer is very much increased if the plunger is negative, and weaker if the plunger is positive. There are occasional impulses of intensity much greater than the normal ; this can be shown even when using an ordinary tapper key. The author investigates the phenomenon, and shows it to be a resonance effect, depending upon the resistance, self-induction, and electrolytic capacity of the circuit at the moment of interruption. It is to be noted also that the resistance is smaller when the small electrode is positive, than when it is negative. The spectrum proves both hydrogen and platinum to be present when the small electrode is negative ; but only hydrogen when the small electrode is positive. A rotating mirror shows that the spark is of shorter duration when the small electrode is positive than when it is negative ; in the latter case the appearance is of a discontinuous band of light of silvery brightness. R. A.

871. *Wehnelt Interrupter.* **Meller.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 179–214, 1900.)—The author shows that by supposing $\frac{di}{dt}$ to vary according to a sinusoidal law, it is possible to explain all the phenomena of interrupted circuits, including those produced by the Wehnelt and Moor interrupters. The interruption must be considered not as the introduction of an infinite resistance but as the introduction of a capacity. Although this gives only a rough approximation to actual occurrences, it introduces no essential error. E. E. F.

872. *Siemens and Halske's Rail-bond Tester.* **J. A. Montpellier.** (Électricien, 21. pp. 105–107, Feb. 16, 1901.)—This apparatus comprises a pair of contacts *a*, *b*, adjustably mounted on a graduated bar of insulating material which is provided with a handle, and a third contact *c* which is mounted on a separate handle. A differential galvanometer is also provided of the Deprez-d'Arsonval type, in which the two coils on the movable frame are suspended between two thin strips of bronze stretched by spiral springs. The apparatus is used as follows:—The two terminals on the bar are placed on the rails, one on each side of the joint, and the separate terminal on one side thereof along one of the sections of the rails, the centre contact *b* being connected to the common terminal of the galvanometer coils and the outer contacts *a*, *c* to the separate ends of the coils. The movable contact *c* is then adjusted until the pointer stands at zero. If $l =$ the distance along the undivided rail between the contacts $b\,c$; $l' =$ the distance across the joint between the contacts $a\,b$; and $p =$ weight per metre of the rail in kilos, the resistance of the joint is—

$$0.25 \times \frac{l - l'}{p} \times 10^{-3} \text{ ohms.}$$

C. K. F.

ALTERNATING CURRENTS AND MAGNETISM.

873. *Sinusoidal Currents.* **M. Wien.** (Phys. Zeitschr. 2. pp. 245–247; Discussion, p. 247, Jan. 19, 1901. Paper read before the 72nd Naturforscherversammlung at Aachen.)—The ideal would be continuous and uniform sinusoidally oscillating currents of any frequency, say from 1 to 10^{12} per second. Alternating currents, to be now described, do not attain this character till their frequency is at least over 17,000; and we can scarcely go beyond 50,000, but then, on the other hand, they are nearly sinusoidal, the higher components being reduced to about 1 per cent. of the fundamental. These currents are obtained by a multipolar arrangement analogous to a siren; masses of iron brought successively between the poles of an electromagnet wound with copper wire, in the circuit of which there is a condenser and an inductor. The amplitude of the current then is—

$$\mathrm{E} \div \sqrt{\left\{\mathrm{R}^2 + (n\mathrm{L} - n^{-1}\mathrm{C}^{-1})^2\right\}}\;;$$

and when $n^2 = (\mathrm{CL})^{-1}$, the current is a maximum. But it is only a maximum for the fundamental oscillation; the higher components are left relatively feeble. Incidentally a resonance galvanometer was described which only responds to oscillations of a particular frequency. In Ann. d. Physik, 4. 3. pp. 425–449, March, 1901, the author further develops the subject. A. D.

874. *Magnetic Properties of Matter.* **H. du Bois.** (International Physical Congress at Paris, Report, 2. pp. 460–508, 1900.)—This is a summary of our present knowledge of the suceptibility of materials, solid, liquid, and gaseous, whether simple or compound, including organic bodies; much attention is given to variation in susceptibility with change of temperature and of magnetic field. There are three main divisions to the paper:—

I. *Ferromagnetics.*—These substances are characterised by high, variable susceptibility, and by hysteresis. The members are iron, nickel, cobalt, manganese, at temperatures below the transformation-point. (Above this point, which is 750° for iron, they must be placed among paramagnetics). Iron, its amalgams and alloys with antimony, aluminium, &c., also its oxides and sulphides are fully treated, the range of temperature being in some cases from — 200° C. to + 1,400° C. Some mention is also made of other members of the group.

II. *Paramagnetics.*—In this division the substances have positive but small susceptibility and no hysteresis.

The members are several metallic groups, *e.g.*, the platinum and aluminium groups, the ferromagnetics above the transformation-point, a great number of salts, also oxygen and ozone.

It is impossible yet to say that paramagnetic substances in solution are strictly insensible to changes in field, but the evidence points that way. P. Curie has found a principle, which the author considers of great importance, and calls *the Law of Curie.*

Let
$$\begin{cases} S = \text{specific magnetisation,} \\ \chi = \quad ,, \quad \text{susceptibility,} \end{cases}$$

$$\therefore S = \frac{\text{magnetic moment}}{\text{mass}} = \frac{\text{magnetic intensity}}{\text{density}};$$

then—
$$\chi = \frac{S}{H},$$

and Curie's Law states that—
$$\chi\theta = C,$$

where θ is the absolute temperature,
and C is a constant (Curie's constant) depending on the substance.
As an example, $FeSO_4$ solution gives—

θ	285°	319°	381°
$C = \chi\theta$	0·0245	0·0241	0·0241

It will be observed that the law of Curie states that the specific susceptibility varies inversely as the absolute temperature, *i.e.*, inversely as the kinetic energy of thermic movements. A remarkable table is also given, showing how the members of any group of salts are related together by means of Curie's constant.

III. *Diamagnetics.*—These bodies have susceptibility negative and independent of the field, also no hysteresis. The list includes bismuth, phosphorus, antimony, water, and many gases.

One general characteristic of all the bodies is that susceptibility diminishes as temperature rises, but much less than for paramagnetics. Often the change is inappreciable; hence for these the law of Curie does not hold. Water, a most important case, is fully dealt with. P. E. S.

875. *Magneto-kinetic Top.* **H. du Bois.** (Archives Néerlandaises, 5. pp. 242–251, 1900.)—Several writers have on theoretical grounds doubted the existence of diamagnetism, and Siertsema has shown that starting from Maxwell's theory, negative magnetism is an absurdity. But, on the other hand, diamagnetic facts can be experimentally shown without any doubt. The author, therefore, has devised the above instrument to illustrate para- and dia-magnetic phenomena, the top being the analogue of the ultimate magnetic particle, which he calls the *magnecule.* Imagine a permanent steel magnet placed in a magnetic field and capable of turning round an axis, which can form with the magnetic axis and with the field any angle whatever. Such a state of things can be realised by mounting the magnet in a complex

gyrostat—the magnetic field being produced by coaxial bobbins which can be set at any inclination to the horizon. Suppose that the axis of rotation is vertical and the magnetic axis also vertical; then when the top is set spinning, the magnet will tend to set horizontally, where there is kinetic stability. Remembering this, we have two cases :—

I. *When the axis coincides with the field.* The field tends to bring the magnet to point along it, but if there is any spin at all, it will require an infinite field to make it reach that limit. Also supposing the spin to be considerable, it is evident that the movement of the magnet will be small and independent of the strength of field, at any rate for small fields, but the movement will be inversely as the kinetic energy of the rotation. Thus the magnetic moment of the magnet (1) will have a *positive* increment; (2) will be independent of the field, at first; (3) will vary inversely as the kinetic energy of rotation, but this implies that for the magnecule, suceptibility will vary inversely as the absolute temperature. The first two conditions are well known for *paramagnetic* bodies, and the third condition is in accordance with the Law of Curie [see preceding Abstract] for them.

II. *When the axis is perpendicular to the field.* The magnet will now remain always in a horizontal plane (as it was before the field was put on); but as the magnet rotates, its magnetic moment will have a positive current when the + pole points to the N., and a negative increment when the — pole points to the N. When the field is intense, there will be a retardation in the rotation when the magnet moves through 180°, followed by an acceleration in rotation through the next 180°. On integrating round a complete turn the increment in magnetic moment will be found to be *negative.* Thus in this case (1) the susceptibility is negative; (2) for small fields it is independent of the field; (3) the susceptibility varies inversely as the kinetic energy of rotation. Here, then, we have the analogue of *diamagnetism.*

There are other applications of the top, *e.g.*, the Earth. This has a magnetic axis inclined at about 20° to its axis of rotation. What would be the influence of a solar or cosmic field on the Earth's motion?

The most modern conception of the magnecules supposes that the Ampere currents are really the convection currents of the charged ions as satellites revolving round the atoms as their planet. It will be seen that the magneto-kinetic top is in no way at variance with that conception. P. E. S.

876. *Physical Modifications due to Magnetisation.* **Hurmuzescu.** (International Physical Congress at Paris, Report, 2. pp. 557–567, 1900.)—From very many experiments it can be shown that the state of magnetisation has some connection (unknown to us) with the structure of the body magnetised. Thanks to Maxwell's theory the existence of tensions has become familiar to us—but when these principles are put to the test the results of different experimenters are at variance with one another. The author divides his remarks into two groups.

I. *Diverse Modifications.* (*a*) If magnetisation is accompanied *simply* by orientation of particles, then in a homogeneous, isotropic body there should be no change in volume on magnetisation. It can be shown on general reasoning that—

$$dW = MdI - pdv,$$

where dW is the total variation of internal energy, M is a function of the field, and p and v are the pressure in, and volume of, the body; hence, by further reasoning, it can be shown that when the field increases the volume of the body should decrease. The author has examined several solutions of iron salts and finds a decrease as anticipated. Hence the simple orientation theory is insufficient. (*b*) The resistivity of iron and nickel increases and that of bismuth decreases on account of magnetisation, but the resistivity of solutions of salts of iron seems to be unaffected. (*c*) The author has not been able to perceive any influence by magnetisation on the transport of ions.

II. *Electromotive Forces due to Magnetisation.* If a magnetised iron rod and an unmagnetised one be placed in some acid which attacks them, it will be found that on completing a circuit a current will flow in the sense that the magnetised rod acts as the positive pole of the cell; *i.e.*, the current leaves the cell by it. In investigating this point the author uses a capillary electrometer to measure e.m.f., and takes special care to eliminate polarisation by having very small contact areas. We have the following form of energy in the system:—(1) Magnetic energy in each of the two poles, and in each of the adjoining liquids; (2) mechanical energy due to tension in the metal; (3) electric energy due to the potentials of each of the two poles and of each adjoining liquid; (4) any other form of energy, *e.g.*, heat energy. Thus an energy equation can be formed; and it can be reduced by various suppositions to the simple form—

$$E = \frac{l}{\delta} \cdot \frac{I^2}{2k},$$

where E = e.m.f., l = electro-chemical equivalent, δ = density of the solid I and k are intensity and susceptibility.

In his investigations the author found that iron (when $H = 2{,}000$ c.g.s.) has $E = 0{\cdot}01$ volt, whilst nickel, for the same field, has $E = 0{\cdot}001$ volt, and bismuth has $E = 0{\cdot}0001$ volt, and in the opposite sense to iron and nickel; these numbers express the *order* of the effect.

It is important to notice that in the above experiments the surface touching the liquid is *not* made a magnetic pole; if, on the other hand, we dispose the electrode so that the surface of contact *is* a pole, then the e.m.f. is much smaller and is sometimes positive, sometimes negative, according to the nature of the liquid. To sum up, we notice that (1) magnetic bodies become by magnetisation less susceptible to attack by acids than when unmagnetised; (2) the neutral pole is carried (in ions) to the magnetised pole; (3) in bismuth, and other diamagnetics, these properties are reversed. P. E. S.

877. *Unipolar Induction.* **E. Hagenbach-Bischoff.** (Archives des Sciences, 11. pp. 5–47, Jan., and 142–160, Feb., 1901.)—Lecher having lately published a paper [Abstract No. 94 (1900)] on the rotation of a magnet when traversed by a current, in which he condemns the generally accepted explanation of this phenomenon, the author has conducted a series of experiments with the view of showing that the action between a current and a magnetic pole is fully accounted for by Biot-Savart's law.

A round-bar magnet is pivoted vertically in mercury cups so as to be capable of rotation about its axis; if the magnet be rotated through a pulley, the e.m.f. induced can be measured between either mercury cup and the centre of the magnet, or, if a current be passed through the magnet at these points, the turning moment produced can be measured by the angle through which the magnet turns when suspended by a bifilar suspension. Starting from Biot-Savart's law, the author deduces that

$$D = -e = -2\mu,$$

where D is the moment of the couple produced by unit current passing through the magnet, e is the e.m.f. produced by unit angular velocity, and μ is the strength of the magnet pole. The value calculated for D and $-e$, from the dimensions and strength of the magnet, is 296, while that found by experiment is 322 for D and 320 for e. As in his calculations the author had assumed the magnetism to be concentrated at points in the bar distant five-sixths of the length of the magnet, he considers the agreement between theory and experiment sufficiently close to prove the applicability of the Biot-Savart law. If the e.m.f. be measured at some point on the magnet other than the centre, it is found to be smaller the nearer the point is to the pole. Similar experiments are made with a magnet provided with a circular mercury trough of insulating material fixed to it at the centre of its length; connection between the mercury and the magnet is made at various points of the latter by copper wires of various shapes, the terminals for introducing the current or for measuring the e.m.f. being the mercury trough and one of the mercury cups. The author gives the calculations for various forms of circuits in detail, and finds the results in every case confirmed by experiment. The author next experimented with an arrangement similar to Lecher's, consisting of two rod magnets mounted parallel to, and one on each side of, the vertical axis; currents could be introduced at either of the mercury cup pivots or at an annular mercury trough, and could be passed through the axis, or through one or both of the magnets. In these experiments, also, the experimental results are in close agreement with those calculated from theory. In every case it is only in the parts of the circuit parallel to the magnets that the current has any influence on the rotation. In the second part of the paper the author describes König's apparatus, which consists of a number of U-shaped magnets, arranged in radial planes, with all S poles at the centre and all N poles on the circumference of a circle; a metal cylinder, embracing the central poles, is capable of rotation about a vertical axis. When a current passes along the cylinder, the author deduces the moment between the cylinder and the bundle of magnets to be $2i\Sigma\mu$, where i is the current and μ the pole-strength of each magnet. This is in complete agreement with Fleischmann and König's experiments. The author finally devotes fifteen pages to a discussion of Biot-Savart's law, and Ampère and Grassmann's formulæ, and concludes as follows: Referring to the arrangement where a single vertical magnet has fixed to it an annular mercury trough, the current passing from the upper mercury cup to the middle of the magnet, and thence along a horizontal wire to the mercury trough; the rotation of the magnet may be explained, according to Biot-Savart's or Grassman's laws, by internal forces only, the external portion of the circuit from the mercury trough to infinity being inactive; on the other hand, when explained according to Ampère's formula, the internal forces counteract one another, and the effect is due to the external forces produced by the portion of the circuit from the mercury trough to infinity. G. H. B.

378. *Unipolar Induction.* **E. Lecher.** (Ann. d. Physik, 3. 3. pp. 513–521, 1900.)—The author examines the significance of Pohl's experiments both from Faraday's and König's point of view, and shows that the old Biot-Savart rule of the rotation of a "pole" about a linear conductor, without taking the remainder of the circuit into account, leads to conclusions which are contradicted by experiment. The usual explanation of Pohl's rotation as a motion of a pole along the circular lines of force surrounding a conductor cannot be maintained. The rotation is due to the remainder of the circuit, which hitherto was left out of account. [See further Abstract No. 377 (1901).]

E. E. F.

879. *Magnetostriction.* **H. Nagaoka.** (International Physical Congress at Paris, Report, 2. pp. 536–556, 1900.)—*Magnetostriction* implies the volume change of a substance when magnetised. A considerable amount of the work in this report will be found in Phil. Mag., vol. xlvi. [see Abstracts Nos. 714 (1899) and 1097 (1900)]. But the whole subject is in this instance treated more fully and widely. Much of the discussion turns on the expressions derived by Cantone from Kirchhoff's principles, viz.—

$$\frac{\delta l}{l} = \left(\frac{4\pi k^2}{3}\,\frac{1+\theta}{1+2\theta} + \frac{k-k'}{2(1+2\theta)} - \frac{k''}{2}\right)\frac{\mathrm{H}^2}{\mathrm{E}},$$

$$\frac{\delta v}{v} = \left(\pi k^2 + 3\,\frac{(k-k')}{4} - \frac{k''}{4}\right)\frac{\mathrm{H}^2}{\mathrm{K}(1+3\theta)},$$

where l and v are the length and volume of the specimen; H is the magnetic field; E and K are Young's Modulus and Rigidity; θ is given by the expression, $\frac{\mathrm{E}}{2}\,\frac{1+2\theta}{1+3\theta} = \mathrm{K}$; k, k', k'', are constants depending on the substance. A considerable amount of information has been accumulated on the relation to one another of the following variables:—(1) Longitudinal field, (2) circular field, (3) longitudinal stress, (4) torsional stress, (5) change in length of the substance, (6) change in volume of the substance.

Since we may observe the variation of one of these when one or more of the others vary, it is obvious that for complete investigation of the whole series a great amount of work would be required. All the known data are tabulated in this report, but the author considers that it is principally for the interior of the magnet that difficulties arise. To the difficulties of theoretical interpretation of the subject are added the difficulties of experimental verification. We require accurate knowledge of (1) elastic constants, (2) permeability and other magnetic factors, (3) deformation of the substance, (4) the strains set up in the substance. The subject is still in its infancy, and there is scope for abundant future investigation. P. E. S.

880. *Torsional Magnetostriction in Strong Transverse Fields.* **C. Barus.** (Amer. Journ. Sci. 10. pp. 407–418, Dec., 1900.)—The author discusses his experiments on this subject and illustrates the phenomena by means of a mechanical model. The results of the experiments indicate that the effect of longitudinal magnetisation is an increment of rigidity in all paramagnetic metals, whereas the permanent effect of a transverse or a circular field is relatively inappreciable so far as rigidity is concerned. This conclusion is at variance with much of the earlier work on the subject, but the author considers that the step-for-step march towards this result contained in the experiments is not to be evaded. The suggestions of the model agree with the result found. The quantity considered is the *permanent* effect of magnetisation on rigidity, *i.e.*, that which persists after making and breaking the field many times. Besides this there is a very striking temporary effect of marked relative value, the relation of which to viscosity is to be considered in a future paper. J. J. S.

881. *Apparent Hysteresis in Torsional Magnetostriction and its Relation to Viscosity.* **C. Barus.** (Amer. Journ. Sci. 11. pp. 97–110, Feb., 1901.)—The author describes a series of experiments made with iron and nickel wires by twisting the wire alternately back and forward over a definite angle within the elastic limits, and examining the change of rigidity produced by circular

or by longitudinal magnetisation immediately after each twist, and after several repetitions of the magnetisations. It is shown that the effect produced by the first magnetisation after any twist is very different from those produced by subsequent magnetisations, the former being viscous and temporary in character, the latter elastic and permanent. When a wire is strained, certain groups of molecules lag behind the stress; this lag may be annulled gradually by lapse of time or by rise of temperature, but it is suddenly annulled by magnetisation. Thus the first magnetisation after any twist has been imparted to the wire reconstructs the magnetic configurations; the subsequent magnetisations merely deflect the set molecular magnets, thus increasing the rigidity without the accompanying viscous effect. W. C. H.

882. *Electric Tramways and Galvanometric Disturbances.* **H. Chevallier.** (Soc. Int. Élect., Bull. 17. pp. 434–436, Nov., 1900.)—At Charlottenburg the disturbances of the electric tramway system render galvanometric measurements useless within a distance of 4 km. from the feeders. At Potsdam magnetometric observations are interrupted 10 km. from the feeders. At Spandau similar instruments are affected at 1 km. The writer gives figures showing the extent of the disturbances at Bordeaux. R. A.

883. *Relation between Solar Activity and the Diurnal Range of the Declination.* **A. Angot.** (Comptes Rendus, 132. pp. 254–257, Feb. 4; and pp. 317–320, Feb. 11, 1901.)—Angot has applied Fourier analysis to the declination records at Parc Saint Maur and Greenwich, and considered how the values of the coefficients vary with the number of sunspots. He supposes the diurnal variation to be due to a normal wave, corresponding to the condition of the sun where no spots are visible, and a disturbing wave which is a function of the number of spots. He concludes that the numbers obtained clearly indicate the influence of the number of spots in the diurnal range of declination. W. W.

MEDICAL ELECTRICITY.

884. *Electrolytic Treatment of Uratic Deposits.* **H. Bordier.** (Archives d'Él. Médicale, 8. pp. 529–532, Nov., 1900.)—In applying the electrolytic treatment to patients suffering from insoluble uratic deposits in the limbs, the author has observed that besides having the lithium of the lithium chloride solution carried by the current into the body, as evidenced by spectroscopic analysis of the urine, the uric acid is also carried out of the body. A deposit formed in the electrolytic bath was found to contain uric acid, calcium carbonate, and traces of lithium. The calcium carbonate came from the water in which the lithium chloride was dissolved.

While operating to remove the largest deposits, it was found that those deposits which had been treated electrolytically were soft like cream, and that those which had not been so treated were hard as stones. J. B. H.

REFERENCE.

885. *Atmospheric Electricity.* **H. Benndorf.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 923–940, 1900.)—A mathematical inquiry into the relations between the form of the earth's surface and the local atmospheric potential slope. The method is based on a development of the theory of proof-planes, applied to a number of typical configurations. A. D.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

886. *Spectroscopy of Atmospheric Gases.* **Rayleigh.** (Phil. Mag. 1. pp. 100–105, Jan., 1901.)—*On the Visibility of Hydrogen in Air.*—Gautier has found by chemical methods that air normally contains about $\frac{2}{10000}$ of hydrogen in addition to variable amounts of hydrocarbons. This has led the author to repeat some experiments he made on the same subject in 1897, and to further investigate the subject. He finds as before that the C line in the spark spectrum of air at atmospheric pressure is nearly, but never quite, obliterated by careful drying of the air. He also finds that an addition to the dried air of $\frac{1}{5000}$ part of hydrogen (by volume) causes a marked increase in the visibility of C, the increase being such that one could easily believe that the proportion of hydrogen actually operative had been doubled. This conclusion would be in precise agreement with Gautier's result, could we assume that the smaller quantity of hydrogen really accompanied the air. But the facts now to be recorded render this assumption extremely doubtful.

The visibility of C with ordinary air is not perceptibly diminished by passing the air over red-hot cupric oxide, although the author's former experience showed that hydrogen purposely introduced into nitrogen could be so far removed by cupric oxide, that the weight remained sensibly unaffected, although $\frac{1}{10000}$ of residual hydrogen was expected to manifest itself. When air with $\frac{1}{5000}$ of hydrogen is passed over cupric oxide, the additional hydrogen appeared to be removed.

Nitrous oxide prepared from ammonium nitrate and also as supplied commercially in iron bottles, and oxygen prepared from permanganate of potash show the C line of about the same intensity as with air. These experiments indicate the possibility of the hydrogen present being evolved from the glass and electrodes of the sparking chamber. Experiments upon the visibility of the C line in vacuum tubes have shown a much less degree of sensitiveness, air containing 2 per cent. of hydrogen showing the C line of about the same brightness as the spark spectrum of ordinary moist air.

Demonstration at Atmospheric Pressure of Argon from very small quantities of Air.—The nitrogen is removed from 10 or 15 c.c. of air by sparking over dilute alkali, and the spectrum of argon is easily recognisable in the spark spectrum of the residue, even when the argon is diluted with two or three times its volume of oxygen. The arrangement used is described in detail, being suitable for a student's experiment.

Concentration of Helium from the Atmosphere.—A constant stream of carbonic acid gas (3 litres per hour) is maintained for, say, 14 hours through a vertical diffusion tube open above to the atmosphere. This tube is about 40 cm. long and of about 5 cm. diameter. The gases of the atmosphere diffuse downwards into the tube, but the heavier constituents are held at bay by the stream of carbonic acid. A continuous stream is drawn off from a point about half-way down the diffusion-tube, and after the carbonic acid is absorbed by alkali the residue is collected. The residue is a small quantity of atmospheric gases in which nitrogen and helium are relatively much concentrated. This lateral stream is about 250 c.c. per hour, and is maintained by means of a sprengel pump drawing the gases through the walls of a short length of tobacco-pipe. After removing nitrogen in the usual way, the final residue, in the experiment in which D_3 was best seen, was about

0·25 c.c. Argon was plainly visible, and probably constituted the larger bulk. Success depended on precautions taken to avoid the presence of gases, and especially of argon, which had not undergone diffusion, but had come from the carbonic acid generator. J. B. H.

887. *Absorption Spectra: Law of Auxochromic Groups.* **P. Lemoult.** (Soc. Franc. Phys., Bull. 160. pp. 3–4, 1901.)—A group which unites together several aromatic nuclei is a chromophore, the whole forming a chromogen, the nature of the grouping leading to a classification of colouring matters. NH_2 or OH groups in "privileged positions," usually *para-*, in relation to the chromophoric bond, are called *auxochromes:* the former are of three kinds—NH_2 or primary, NHR′ or secondary, and NR′R,″ where R′ and R″ are fatty or aromatic radicles. Alkyls, NO_2, SO_3H, COOH, and even NH_2 and OH in "non-privileged" positions, are called *non-significant;* they add nothing to the colouring function, however important in other ways. Coloured solutions in molecular dilution and of constant thickness, according to the author, give usually a narrow band in the red and often a wider one towards the green or violet. The centre of the red band is constant for the same family in bodies only differing by non-significant groups, or by nitrogenous auxochromes, which are non-tertiary, but is displaced on varying the number of the latter, which are tertiary. These facts together constitute "the law of nitrogenous auxochromes." For triphenylmethane colours, those with two tertiaries with or without a non-tertiary give a red band between 0·70 μ and 0·66 μ, those with three tertiary auxochromes give a band between 0·68 μ and 0·65 μ. The red band of the family is more persistent than any other individual character. Lemoult has found that indophenols obey the same law. S. R.

888. *Absorption of Light by Indophenols.* **P. Bayrac** and **C. Camichel.** (Comptes Rendus, 132. pp. 338–340, Feb. 11, 1901.)—All indophenols derived from p-anudo-dimethylamme, when dissolved in alcohol give an analogous spectrum with a characteristic red band, and do not conform to Lemoult's law of auxochromes [Comptes Rendus, 131. No. 21; see also preceding Abstract]. This band commences in the visible spectrum and extends into the infra-red. S. R.

889. *Absorption Spectra of Indophenols and of Derivatives of Triphenylmethane.* **C. Camichel** and **P. Bayrac.** (Comptes Rendus, 132. pp. 485–487, Feb. 25, 1901.)—The authors further show that Lemoult's law of auxochromes does not apply to the coloured derivatives of triphenylmethane [see preceding Abstracts]. S. R.

890. *Molecular Rotation of Normal Acidyl Derivatives of Diethyl l-Malate.* **H. Reitter.** (Zeitschr. Phys. Chem. 36. pp. 129–167, Feb. 8, 1901.)—According to the theory of the asymmetric carbon atom elaborated by Guye, the optical rotation depends in the first place on the relative masses of the radicles with which the asymmetric carbon atom of the molecule is combined, and the specific rotation is proportional to the so-called asymmetry-product, the value of which is given by the following expression, in which a, b, c, and d are the masses of the four radicles:—

$$P = \{(a-b)(a-c)(a-d)(b-c)(b-d)(c-d)\}/(a+b+c+d)^6.$$

In the case of several homologous series which have been examined it has been found that proportionality between the specific rotation and the asymmetry-product does not exist, and in some cases the two magnitudes do not vary in the same manner. The compounds examined by the author comprise the first normal acidyl derivatives of lævo diethyl malate and a description of their methods of preparation and of their properties is given. The results obtained are given in the following table, the first column containing the names of the various acidyl derivatives :—

	Mol. Wt.	Density 20°/4°	$[\alpha]^{20}_{D}$	$[M]^{20}_{D}$	P × 10^6
Acetyl	232	1·1169	— 22·60	— 52·43	17
Propionyl ...	246	1·0926	— 22·79	— 56·06	0
n-Butyryl ...	260	1·0735	— 22·75	— 59·15	0
n-Valeryl	274	1·0551	— 21·38	— 58·56	11
n-Capronyl ...	288	1·0420	— 20·30	— 58·46	26
Œnanthyl ...	302	1·0289	— 19·30	— 58·27	44
Caprylyl	316	1·0162	— 18·21	— 57·53	61
Pelargonyl ...	330	1·0073	— 17·24	— 57·17	77
Caprinyl	344	1·0011	— 16·61	— 57·14	91

These numbers furnish a further contradiction to the supposed proportionality between specific rotation and asymmetry-product, as when the former is at its maximum the latter has the value 0. The numbers obtained for the molecular rotation confirm what has been previously found for other homologous series, namely, that the molecular rotation tends to become constant as the series is ascended. T. H. P.

891. *Apparent Symmetry in Crystals.* **F. Wallerant.** (Comptes Rendus, 132. pp. 178–180, Jan. 21, 1901.)—When the network and the fundamental particle of a crystallised body possess a common element of symmetry, this element is found also in the crystalline form and in the ellipsoid of optical elasticity. In most cases the converse of this also holds, and it has hence been assumed that it holds generally, although in some cases an axis of the crystal and of the optical ellipsoid may not be of the same order of symmetry as the network, as will be seen from the following considerations. Iodargyrite shows hexagonal symmetry in its crystalline form, but its network and its fundamental particle have only a ternary axis, which has, however, an apparent binary symmetry. This view is supported by the facts—(1) that the parameters of the vertical and secondary axes are in the ratio 1·2294 which is almost exactly $\sqrt{3}/\sqrt{2}$; so that if the network were hexagonal, there would be no relation between the vertical and secondary axes ; (2) that the crystals twin along the face $(10\bar{1}2)$ which makes an angle of 54° 38′ with the ternary axis ; this arrangement cannot be explained if the crystal be hexagonal, whilst if the symmetry be cubic, the plane of twinning coincides with a rhombic dodecahedron face, which makes an angle of 54° 44′ with the ternary axis of the cube ; (3) that when heated to 146° iodargyrite becomes cubic, reverting to its original form on cooling ; as this change is effected without loss of transparency, it follows that the network, which is cubic above 146°, must be rhombohedric and not hexagonal below that temperature. As further examples may be cited rutile and other minerals regarded as quadratic, but which are really monoclinic. It hence becomes necessary to introduce into crystallography a new idea, that of an axis of apparent symmetry, which is such that when the network is rotated round it through an angle of $2\pi/n$, any particular row or plane of the network is brought into coincidence with another row or plane, but the coincidence does not hold for the whole network. Another necessary condition for a row being such an axis of apparent symmetry is that the fundamental particle exerts, in symmetrical directions, equal actions on external media such as the ether. T. H. P.

892. *Crystallisation of Solid Metals by Pressure.* **W. Campbell.** (Phys. Soc., Proc. 17. pp. 337–338 ; Discussion, p. 338, Dec. 1900 [Abstract].)—When a button of slowly-cooled tin is hammered it assumes a fine crystalline structure. Also in preparing sections of tin, particles of the metal cling to the file and tend to tear the surface ; this effect is not immediately noticeable, but on etching the polished surface, there appear, besides the usual structure of the tin, irregular outlines of much smaller crystals, and if the tearing action of the file has been extreme, these crystals may conceal the original crystalline formation produced by cooling. A similar crystallisation is brought about on the faces of a saw-cut. A copper-tin alloy containing 1 per cent. of copper, gives exactly the same effects as pure tin. That the crystallisation exists only on the surface of the metal is shown by gradually wearing away the surface by continually polishing, when it is found that the crystals slowly disappear, giving place to the ordinary structure. The effect is not due to local heating, since if the file is kept perfectly clean no crystals are formed. T. H. P.

893. *Crystal Symmetry.* **W. Barlow.** (Phil. Mag. 1. pp. 1-36, Jan., 1901 Published also in Groth's Zeitschr. f. Krystallographie.)—In seeking a new definition of crystal symmetry, the author points out that it is necessary to have regard not only to the crystal form of such bodies but also to the physical properties, such as their behaviour with polarised light, and their different degrees of vulnerability in different directions when attacked by solvents. The derivation from first principles of the thirty-two classes of crystal symmetry, now generally recognised, was originally achieved by Hessel, and rediscovered much later by Gadolin; both writers base their work on the validity of Haüy's law of rational indices as applied to crystal faces, and discuss the symmetry solely with reference to face directions. Barlow now shows that this treatment lacks generality, and that it leads in some cases to crystals being referred to types of symmetry higher than that characterising their internal structure. He submits a definition of homogeniety of structure which is independent of face directions, and proves that this definition suffices as a basis both for the deduction of the thirty-two classes, and for that of Haüy's law connecting homogeneous planes and lines of points occupying identical situations. R. A.

894. *Reaction Velocity, and Solubility.* **W. D. Bancroft.** (Archives Néerlandaises, 5. pp. 46–48, 1900.)—The recent experiments of Buchböck [see Abstract No. 2270 (1900)] have shown that the viscosity of the solvent is one of the factors determining the velocity of a reaction. The fact that the order of the solvents is not the same for all reactions shows that other influences than that of viscosity come into play, and the author indicates the effect produced on the velocity by the solubilities of the reacting compounds. Taking the case of a monomolecular reversible reaction in a so-called indifferent solvent, equilibrium occurs when $k_1c_1 = k_2c_2$ and the velocity of reaction at any moment is given by : $dc/dt = k_1c_1/A - k_2c_2/A$, the factor A representing the effects due to viscosity and to other as yet unclassified causes. If now another solvent be employed in which the first substance is less soluble and the second more soluble than before, k_1 becomes replaced by the larger constant k'_1 and k_2 by the smaller k'_2, the equilibrium being displaced to the side of the second substance. If the change of the solvent introduces no disturbing elements other than the change of solubility, the velocity of reaction at any moment will be: $dc/dt = k'_1 c_1/A - k'_2 c_2/A$. Hence a decrease in the solubility of one of the reacting substances tends to increase the rate at which the other is formed. It does not follow that the velocity of reaction will be increased in any particular case, because it is extremely improbable that the change of solubility will be the only change produced by the substitution of a new solvent, and it is conceivable that there might be an increase in the factor A which would more than counterbalance the changes in k_1 and k_2. T. H. P.

895. *Microscopic Examination of Tool-Steel.* **E. Heyn.** (Tech. Versuch. Berlin, Mitth. 18. pp. 191–202, 1900.)—In order to ascertain whether the working-edge of a tool has become richer or poorer in carbon than the rest of the tool, a fragment is heated in an atmosphere of nitrogen, ground and polished, and then etched with a mixture of 1 part hydrochloric acid and 99 parts alcohol. In steels containing less than 0·9 per cent. carbon the relative proportion of carbon may be judged from the quantity of yellowish perlite which can be seen, as compared with the clear ferrite (pure iron); in steels containing more than 0·9 per cent. carbon, the white cementite may be used as a test in a similar way. Directions are also given for detecting welds and hardening cracks.

In order to ascertain whether the steel has been burnt in making the tool, whether it has been tempered after hardening, from what temperature it was quenched in the hardening, and whether it was overheated in hardening, it is necessary to know the influence of these changes on the minute structure of steel, and experiments are described which were carried out with a steel containing 0·55 per cent. of carbon in order to obtain some of the necessary data. T. M. L.

896. *Eutectic (Cryohydric) Curves in Systems of Three Substances, Two being Optical Antipodes.* **J. H. Adriani.** (Zeitschr. Phys. Chem. 36. pp. 168–172, Feb. 8, 1901.)—Bruni has shown that the cryohydric curve for solutions of various mixtures of two optical antipodes varies in form according as the mixture of the two isomerides separates from solution as a racemic substance, as mixed crystals, or as a mixture. In place of the term "cryohydric" curve the author suggests "eutectic" as applying to other solvents as well as water, and to eliminate the false distinction made between solvent and dissolved substance the former is termed the "third body." By choosing for the third body substances having different melting-points, it is found that in general the region of temperature of the eutectic curve is highest in the case of that third body which has the highest melting-point, and any change in the nature of the inactive substance with change of temperature will be accompanied by a change in the form of the eutectic curve. The author applies this method to the case of the camphoroximes, the racemic modification of which he has previously [see Abstract No. 1700 (1900)] shown to change above 103° into mixed crystals. Four solvents—naphthalene, phenanthrene, benzoin, and

anthracene—were employed, and the various eutectic temperatures for the different mixtures are given in the following table :—

Percentage.		Naphthalene M. Pt. 81·4°.	Phenanthrene M. Pt. 99·4°.	Benzoin M. Pt. 137°.	Anthracene M. Pt. 213°.
d-oxime.	*l*-oxime.				
100	0	61·0°	76·2°	100·2°	109·2°
95	5	60·0	—	—	—
90	10	59·6	75·6	99·1	107·6
80	20	59·2	74·9	98·2	106·8
75	25	59·4	—	97·8	—
70	30	60·1	74·2	97·4	106·2
65	35	60·8	74·8	—	—
60	40	61·3	75·6	97·0	105·8
50	50	61·9	76·2	97·2	105·6

These numbers show that at 60° the eutectic temperature of the *i*-oxime is higher than that of the two antipodes, the difference becoming smaller as the temperature increases until in the neighbourhood of 76° (phenanthrene) the eutectic points of the *i*-compound and of the antipodes are the same. At still higher temperatures the change continues, and the numbers obtained with benzoin indicate that at 97·2° camphoroxime still exists in the form of a racemic substance. The anthracene curve is, however, continuous, showing that at 105·6° *i*-camphoroxime must be regarded as mixed crystals. The transition-point hence lies between 97·2° and 105·6°—a result agreeing with that previously obtained (*loc. cit.*). T. H. P.

897. *Catalysis in Heterogeneous Systems.* **K. Drucker.** (Zeitschr. Phys. Chem. 36. pp. 173–215, Feb. 8, 1901.)—Experimental investigations in chemical kinetics have hitherto been principally confined to homogeneous systems; the author has therefore studied two cases of catalytic reactions in solid-liquid systems, namely, the dissolution of anhydrous chromic chloride and of arsenic trioxide in aqueous solvents. The results of the experiments, full details of which are given in the paper, are summarised as follows: The effect of reducing agents (other substances being inactive) in increasing the velocity of solutions of chromic chloride in water depends (1) on the nature of the reducing agent, no regularities being detected in this respect; (2) on its reduction potential, with which it rises and falls; (3) on its concentration, a similar relation holding. If the reducing agent is soluble with difficulty it is necessary that the solid substance should be present, and the effect produced depends on the surface of the latter and on the contact of the two solid phases. The reaction follows Noyes' and Whitney's relation, the velocity being constant in the initial stages. For slow and very rapid reactions the velocities are nearly proportional to the reduction potential, but for intermediate values this is not the case.

The velocity of solution of arsenic trioxide in water is especially influenced by the presence of hydrogen ions. Noyes' and Whitney's law is found to hold, but the usual influence of the concentration of the catalytic agent was not observed. Hydroxyl ions are also effective; so also is a solution of sodium acetate, in which, however, few hydrogen or hydroxyl ions can be present. Amyl alcohol has a slight retarding action. N.L.

898. *Chemical Kinetics of Homogeneous Systems.* **R. Wegscheider.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 699–792, 1900.)—The author develops a general form of the equations for the velocities of reactions in homogeneous systems at constant volume, applicable to the various kinds of reactions and catalytic effects. By its means he investigates the form of the reaction equations and the external conditions to be fulfilled (1) in order that the velocities of two simultaneously occurring reactions should be in a ratio independent of the time, (2) that the concentration of a substance which is being partially formed and partially broken up by simultaneous reactions should remain unchanged, (3) that the changes in the quantities of two substances should be in a ratio independent of the time. The results are applied to the study of Skraup's constant "transmutation-ratio," and it is shown that such a ratio, determinate, finite, and independent of the time, exists for two substances (1) when the concentrations of both are changed during the reactions in equal stoichiometric ratios, (2) when the velocities of the reactions which change the concentrations of both substances are in a ratio independent of the time. Cinchona is treated as an example. In conclusion the author investigates equations for the velocities of reactions, when the volume changes are taken into account, particularly in the case of gases under constant pressure. The formulæ arrived at are applied to the discussion of Bodenstein's experiments on the formation of water-vapour from Knall gas, and the importance of paying attention to the volume changes that occur is demonstrated. The reaction occurs more slowly at constant volume than at constant pressure. W. E. T.

899. *Dissolution of Solid Metals in Liquid Metals.* **Berthelot.** (Comptes Rendus, 132. pp. 290–291, Feb. 11, 1901.)—The author draws attention to the fact that the phenomenon of solution of a solid metal by a liquid metal is by no means analogous to the solution of a salt or other compound body by water. The action, for example, of a small quantity of mercury in gradually penetrating another metal, such as gold, silver, copper, or zinc, which is thereby caused to swell up and become soft and brittle, is not strictly a case of solution. The author points out that the thermo-chemical data of his experiments on the heats of transformation of the allotropic forms of silver, and on the heats of formation of silver amalgams, are independent of any theory as to the constitution of the supposed metallic solutions. T. H. P.

900. *Determination of the Work Produced by Chemical Change.* **E. Cohen.** (Archives Néerlandaises, 5. pp. 295–305, 1900.)—The vapour tension of crystals of $MgSO_4.7H_2O$ was determined at temperatures between 30·75 and 47·45° C.; from the values obtained the heat of hydration was calculated to be 3,712 cal., the value given by Thomsen's calorimetric measurements being 3,700 cal. Similarly the vapour tension of $FeSO_4.7H_2O$ was determined between 30·67 and 46·43° C., and the heat of hydration calculated to be 1,912 cal. The two vapour-tension curves intersect at 46·6° C., which is thus the transition-point of the system—

$$FeSO_4.6H_2O + MgSO_4.7H_2O \rightleftharpoons FeSO_4.7H_2O + MgSO_4.6H_2O;$$

above this temperature $FeSO_4.7H_2O$ has the lower vapour pressure, whilst below 46·6° the vapour pressure of the $MgSO_4.7H_2O$ is the lower.

If q is the heat of the reaction and P the transition temperature, then the work, A, in calories available at T° (abs.) is given by the equation—

$$A = q\left(\frac{P-T}{P}\right),$$

and in this case $A = 1800 - 5·632T$. T. M. L.

901. *Use of Pyridine for Molecular Weight Determinations by the Ebullioscopic Method.* **W. R. Innes.** (Chem. Soc., Journ. 79. and 80. pp. 261–266, Feb., 1901.)—Pyridine does not favour the association of dissolved substances, acids, alcohols, and phenols having been found to give normal results. Hence this liquid may be used for ebullioscopic molecular weight determinations—a purpose for which it is well fitted on account of its remarkable solvent power for both organic and inorganic compounds. The precautions necessary to obtain accurate results are described in the paper; the constant for pyridine is 29·5. N. L.

902. *Gas-Polarisation in Lead Accumulators.* **C. J. Reed.** (Journ. Phys. Chem. 5. pp. 1–16, Jan., 1901.)—The statement of Nernst and Dolezalek [Abstract No. 671 (1901)] that hydrogen is not liberated with less than 2·3 volts from lead electrodes, as compared with 1·7 volts for platinum electrodes, is incorrect; on the contrary, hydrogen gas is evolved electrolytically in unlimited quantities from dilute sulphuric acid with electrodes of pure metallic lead when the e.m.f. is less than 0·5 volt. To realise this experimentally it is necessary to employ a very large anode of finely divided lead, since the surface rapidly becomes covered with lead sulphate. The reaction which first takes place is expressed by the equation—

$$\mathrm{Pb} + \mathrm{H_2SO_4Aq} = \mathrm{PbSO_4} + 2\mathrm{H} + \mathrm{Aq},$$

and should produce an e.m.f. of 0·12 volt; actually 0·38 volt is required to start the reaction, but the e.m.f. then required to maintain a steady current is less than 0·01 volt.

As soon as the anode is covered with a film of lead sulphate the character of the reaction changes to that expressed by the equation—

$$\mathrm{PbSO_4} + \mathrm{H_2SO_4Aq} = 2\mathrm{H} + \mathrm{PbO_2} + 2\mathrm{SO_3Aq},$$

which, instead of producing an e.m.f., absorbs an e.m.f. of 1·73 volts. If, as in a discharged accumulator, the kathode is not lead but lead sulphate, this must also be reduced, and the reaction—

$$\mathrm{Aq} + 2\mathrm{PbSO_4} = \mathrm{PbO_2} + \mathrm{Pb} + 2\mathrm{SO_3Aq},$$

requires 1·845 volts. If a correction is made for the fact that the acid in the accumulator is of appreciable concentration, slightly higher values would be obtained for the voltage, and these corrected values correspond with the observed e.m.f. of the cell. T. M. L.

903. *Equilibrium of Mixed Crystals with the Gaseous Phase.* **H. W. B. Roozeboom.** (Archives Néerlandaises, 5. pp. 360–365, 1900.)—The case considered is that of a system of two substances which are miscible in all proportions, both in the solid and in the liquid state; it is also assumed that the vapour-pressure curves for mixtures of the two substances in different proportions are continuous and do not show a maximum or minimum. If the vapour pressure is plotted along a vertical axis, and the temperature and percentage composition are plotted along a pair of horizontal axes, the vapour surface consists of two sheets representing the pressure and composition of the vapour in equilibrium with the solid and with the fused mixture respectively. The surfaces representing the vapour pressure of solid and of liquid mixtures of different composition form two separate sheets, which are separated by a small surface representing solid and liquid in equilibrium.

At the melting-point of the mixed crystals three phases are in equilibrium, under the same pressure, the solid phase being richest and the vapour phase poorest, in the less fusible and less volatile constituent. For any temperature between the melting-points of the two constituents a horizontal line of equal pressures can therefore be drawn passing successively through the three boundaries of the surfaces described above. T. M. L.

904. *Dissociation Constants of Alkyl-substituted Succinic Acids.* **W. A. Bone** and **C. H. G. Sprankling.** (Chem. Soc., Journ. 77. and 78. pp. 654–673; and pp. 1298–1310, 1900.)—The authors give the results of a number of measurements of the dissociation constants of alkyl-substituted succinic acids, together with a discussion of the connection between the values obtained and the chemical constitution of the various derivatives. The values of the dissociation constants of such acids should be influenced by (1) the number of substituting alkyl groups, (2) their mass and chemical structure, and (3) the mutual influence of the two carboxyl groups, largely dependent on the distance between them. From observations on anhydride formation, the authors incline to the view that the relative distances of the two carboxyl groups in acids of this series containing the same number of alkyl radicles are practically equal, so that differences in their dissociation constants must be ascribed to the influence of the second factor, namely, mass or chemical structure of the alkyl substituents. The constants for mono-substituted succinic acids are as follows :—

Monomethyl	0·0085	Monoisopropyl	0·0076
Monoethyl	0·0085	Monoisobutyl	0·0088
Monopropyl	0·00886	Monoisoamyl	0·0096

Hence, for these acids, an increase in the mass of the alkyl radicle is accompanied by a tendency to increase in the constant, except in the case of the isopropyl group, which exerts a lowering influence. On comparing the values obtained for the aa_1-dialkyl acids containing one methyl and a second variable radicle, which are as follows :—

	Trans.	Cis.
s-Dimethyl	0·0196	0·0123
aa_1-Methylethyl	0·0207	0·0201
aa_1-Methylpropyl	0·0335	0·0271
aa_1-Methylisopropyl	0·0158	0·066
aa_1-Methylisobutyl	0·0226	0·056
aa_1-Methylisoamyl	0·0236	0·0385

it will be seen that, so long as the variable radicle remains normal, the constant increases with its mass in both the cis- and trans-series. When, however, the variable radicle contains an iso-grouping, a lowering effect is found in the trans-series and a marked increase in the cis-series, these two opposite effects becoming greater as the peculiar grouping of the atoms in the iso-radicle approaches more nearly to the carbon atom to which the carboxyl group is attached. Further, only where the variable radicle is normal are the constants for the trans-acids greater than those for the corresponding cis-isomerides. Similar effects are to be observed in the case of trialkyl acids having two methyl groups attached to the one carbon atom and a third variable radicle to the other carbon atom, thus :—

Trimethyl	0·0320	Dimethylisopropyl	0·0150
Dimethylethyl	0·0566	Dimethylisobutyl	0·0432
Dimethylpropyl	0·0600	Dimethylisoamyl	0·0616

and also in the case of the symmetrically substituted dialkylsuccinic acids, the constants for which are given in the following table :—

	Trans.	Cis.
s-Dimethyl	0·0196	0·0123
s-Diethyl	0·0245	0·0201
s-Dipropyl	0·0250	0·049
s-Diisopropyl	0·0108	0·230
s-Diisobutyl	0·0226	0·056

The general conclusion to be drawn from all these results is that in this series of acids each alkyl group exerts on the dissociation constant its own influence dependent on its mass and structure. In the case of normal substituents, where the effect of mass only has to be considered, it is found that an increase in the mass of a variable radicle is invariably accompanied by an increase in the dissociation constant. With the one exception of cis-symmetrically substituted dialkyl acids, the "structural" effect of the iso-radicles is opposed to the mass effect and its magnitude in all cases depends on the proximity of the iso-linking to the carbon atom bearing the carboxyl group. T. H. P.

905. *Potential between Metals and Non-aqueous Solutions.* **L. Kahlenberg.** (Journ. Phys. Chem. 4. pp. 709–714, Dec., 1900.)—This paper is a continuation of the one referred to in Abstract No. 545 (1900). The author tests the well-known formula of Nernst for cells of the type—

$$\mathrm{Ag} \mid \mathrm{AgNO_3}\ \text{(concentrated)} \mid \mathrm{AgNO_3}\ \text{(dilute)} \mid \mathrm{Ag},$$

with organic solvents. If the degree of ionisation is taken into account, the formula becomes—

$$E = \frac{RT}{ne} \log \frac{S_1 \mu_{s1}}{S_2 \mu_{s2}},$$

in which S_1, S_2 are the concentrations, and μ_{s1}, μ_{s2} are the corresponding degrees of ionisation. Five combinations were tested, with the following results :—

	E.m.f. calculated.	E.m.f. found.
Ag electrodes : N/10 and N/100 $AgNO_3$ in pyridine...	0·052 volt	0·035 volt
„ „ N/500 „ „ ...	0·085 „	0·061 „
„ „ N/1,000 „ „ ...	0·099 „	0·076 „
„ N/8 and N/128 „ in acetonitrile	0·050 „	0·046 „
Cd electrodes : 1 gr. mol. of CdI_2 in 48·9 litres and in 214·7 litres of acetonitrile	0·017 „	0·032 „

Any potential difference between the solutions was neglected. The author concludes that the formula does not apply to non-aqueous solutions. It is noticeable that the only case of approximate agreement is the fourth combination, in which the electrolyte is of high conductivity. W. R. C.

906. *Electrode-Potentials.* **N. T. M. Wilsmore** and **W. Ostwald.** (Zeitschr. Phys. Chem. 35. pp. 291–332, Nov. 2, 1900 ; and 36. pp. 91–98, Jan. 22, 1901.)—The author proposes the name *Electrolytic Potential* for the quantity $\frac{RT}{n}\log P$ of Nernst's theory. In order to carry through the suggestion of Nernst, that the p.d. of hydrogen at atmospheric pressure against an aqueous solution containing hydrogen ions of normal concentration should be *taken as zero* for electro-chemical calculations, the author very fully investigates this particular electrode and describes and figures a suitable form, wherein the gas continually bubbles through the electrodic solution. Reckoning in this way, the p.d. of the normal calomel-mercury electrode comes out to be — 0·288 volt. Incidentally the curious fact is observed that the e.m.f. of the $H_2 - O_2$ gas-cell (normal sulphuric acid) gradually *rises* after the cell is set up, becoming approximately constant after four to six days at the value 1·119 volts (initial value, 1·076 volts). The paper further contains a very exhaustive summary of the literature on the subject, from which the electrolytic potentials of thirty-one elements are calculated, and investigations on various other electrodes, more especially on kathodically-polarised platinum wire-points.

In the second paper the author gives a recalculation of the potentials given by him in a previous paper, on the basis preferred by Ostwald, namely, using the calomel-electrode and taking its p.d. as 0·56 volt. Appended to the original are some remarks by both authors on the *pros* and *cons* of the case, hydrogen- *versus* calomel-electrode as a basis in the determination of p.d.'s in electro-chemistry. [See also Abstract No. 414 (1901).] F. G. D.

907. *Determination of Transport Numbers, and the Influence of Concentration.* **A. A. Noyes.** (Zeitschr. Phys. Chem. 36. pp. 63–83, Jan. 22, 1901.)—In determining the transportation-values for salts, the metal of which cannot be used for the electrodes, the chief difficulty is caused by the formation of acid and alkali at the anode and kathode, and the rapid diffusion of the $\overset{+}{H}$ and $\overset{-}{OH}$ ions into the solution. This makes it necessary to interrupt the experiment when only a few milligrammes have been transported, and largely increases the errors of experiment. In the method now described this difficulty is overcome by neutralising the liquid at the electrodes with solutions of suitable strength of the acid and base of the salt, and measurements of remarkable accuracy can be obtained.

The method has been used to ascertain to what extent the transportation values are influenced by the concentration in the case of the three ternary electrolytes, K_2SO_4, $BaCl_2$ and $Ba(NO_3)_2$. The existence of the ions $K\overset{-}{S}O_4$, $\overset{+}{Ba}Cl$ and $Ba\overset{+}{N}O_3$ cannot be established by measurements of the conductivity or freezing-point of the solutions, and there is no method of estimating them comparable with the determination of hydrogen ions by experiments on inversion and hydrolysis; their presence would, however, have the effect of diminishing the transportation-value of the kathion in the case of K_2SO_4, and of the anion in the case of $BaCl_2$ and $Ba(NO_3)_2$. In the case of barium nitrate at 25° the transportation-values for the kathion were found to be 0·4550 in 0·1 molecular solution, and 0·4559 in 0·02 molecular solution, showing that dissociation into $Ba\overset{+}{N}O_3$ and $\overset{-}{N}O_3$ only takes place to a very slight extent. In the case of potassium sulphate the corresponding values were 0·4931 and 0·4962, showing that not more than 1 per cent. of the salt can be present in the intermediate stage of ionisation. Barium chloride, however, showed a very marked influence of concentration, and gave the values 41·47 and 44·22 in 0·1 and 0·02 molecular solution at 25°; this effect is in the opposite direction to that which would be produced by ionisation into $\overset{+}{Ba}Cl$ and $\overset{-}{Cl}$, and it is suggested that the anion tends to combine with the neutral salt to complex ions such as $\overset{-}{Ba}Cl_3$ or $\overset{-}{B}\overset{-}{a}Cl_4$. Hittorf's values for $BaCl_2$ and $Ba(NO_3)_2$

are widely different from those now given, and show that fresh determinations of the transportation-values of ternary electrolytes are needed. T. M. L.

908. *Calculation of the Ionisation of Strong Electrolytes.* **S. Arrhenius.** (Zeitschr. Phys. Chem. 36. pp. 28–40, Jan. 22, 1901.)—Using Nernst's formula for the e.m.f. of concentration-cells, Jahn has recently endeavoured to prove that the ionic mobilities vary comparatively rapidly with concentration, so that the present method of calculating the degree of ionisation from the conductivity of a solution is incorrect. This conclusion is now contested by Arrhenius. He first of all deduces thermodynamically a formula for the e.m.f. of concentration-cells, which differs from that given by Nernst. For example, in the cases quoted, the difference between the values as calculated from the two formulæ amounts to about 1½ per cent. Arrhenius points out the cause of this difference. It is due to the fact that Nernst's formula results from the summation of three terms, one of which is the p.d. at the junction between two electrolytes containing the same ions but of different concentrations. In calculating this p.d. it is assumed by Nernst that an ion when it passes across this interface from one solution to the other remains still an ion. This, however, is only true for extremely dilute electrolytes.

In order now to test how far the discrepancies observed by Jahn originated from the use of Nernst's formula, Arrhenius calculates from his data the degrees of ionisation by the usual conductivity method, and then employs the values so found to calculate the true e.m.f.'s of the concentration-cells. On comparing these values with those experimentally determined, the difference is found to be small, the average discrepancy being about 1½ per cent. These differences are, at any rate, very much smaller than the differences supposed by Jahn to exist between the ionic mobilities in the weakest and strongest solutions examined by him, and are considered by Arrhenius to be due to the experimental difficulties inherent in the determination of e.m.f.'s. In view of this, Arrhenius considers that Jahn's experiments, instead of overthrowing the old method of determining degrees of ionisation, form a further confirmation of it, and he maintains that the anomalous behaviour of strong electrolytes cannot be explained in the manner indicated by Jahn.

[The thermodynamical formula for the e.m.f. of concentration-cells given by Arrhenius is not new. It has been given recently by Couette and subsequently by Lehfeldt.] F. G. D.

909. *Autoxidation, Theory of Ions, and Galvanic Cells.* **F. Haber.** (Zeitschr. Elektrochem. 7. pp. 441–448, Jan. 31, 1901.)—Hydrogen peroxide is often formed during atmospheric oxidation in accordance with the typical scheme of "autoxidation" $M + O_2 + 2H_2O = M(OH)_2 + H_2O_2$. Taking as an example the conversion of lead to sulphate according to the equation $Pb + H_2SO_4 + O_2 = PbSO_4 + H_2O$, it is shown that this can be resolved into a characteristic anode-reaction—

$$Pb + SO_4 = PbSO_4$$

and a kathode-reaction—

$$O_2 + 2H = H_2O_2,$$

which has been shown by Traube and by Richarz and Lonnes to take place at kathodes of amalgamated gold and other materials. The whole phenomenon is therefore probably, like many other chemical reactions, electrolytic in character. T. M. L.

910. *Liquefaction of Gaseous Mixtures.* **F. Caubet.** (Comptes Rendus, 132. pp. 128–131, Jan. 14, 1901.)—If a mixture of carbon dioxide and sulphur dioxide undergoes isothermal compression, between a certain value of the pressure corresponding to the dew-point and a higher value corresponding to the point of ebullition, or the second dew-point, the system consists of a double mixture, in which liquid and gaseous phases occur. The author applies the limiting lines obtained by him [see Abstracts Nos. 843 and 2004 (1900)] to the determination of the concentrations in these phases, when the temperature and pressure are given. Curves are drawn which represent the connection between the concentrations and the pressure for five temperatures. [See further Abstract No. 625 (1901).] W. E. T.

911. *Relations between the Quantities Characteristic of the Physical State of a Solution.* **N. Schiller.** (Archives Néerlandaises, 5. pp. 118–147, 1900.)—For a given temperature, letting σ_0 signify the specific volume of a pure solvent under pressure p_0, σ the specific volume of the solvent forming a solution of concentration ζ (the ratio of the quantity of the dissolved substance to the quantity of the solvent) under pressure p_0; κ_0, κ the elasticity coefficients of the pure solvent and of the solution, q the osmotic pressure in the solution under the pressure of the vapour arising from it, q_1 the osmotic pressure in the solution of concentration ζ under external pressure $p_0 + q_1$, σ_1 the specific volume of the solvent in the solution corresponding to the pressure $p_0 + q_1$, p_0 the vapour pressure of the pure solvent, p its vapour pressure as modified by the osmotic pressure, the author, neglecting magnitudes of the order $1/\kappa^2$, proves the relations—

$$\frac{\sigma}{\kappa} - \frac{\sigma_0}{\kappa_0} = C\zeta^{\frac{1}{2}},$$

C being an arbitrary constant independent of ζ,

$$\sigma_1 - \zeta\frac{d\sigma_1}{d\zeta} - \sigma_0 = -\frac{1}{2}(p_0 + q_1)C\zeta^{\frac{1}{2}},$$

and—

$$p_0 s_0 \log\frac{p}{p_0} + \sigma_0(p_0 + q - p) + \frac{\sigma_0}{2\kappa_0}(p_0 + q - p)^2 = 0,$$

in which s_0 is the corresponding specific volume of the vapour. These equations are derived from considering the pure solvent and the solution contained in a cylinder fitted with movable pistons, separated by a semi-permeable membrane and subjected to the following isothermal reversible cyclic process. A quantity *dm* of the solvent passes into the solution, the membrane is replaced by a solid wall, and the external pressure on the solution is brought down to p, *dm* of the solvent is allowed to evaporate from the solution, separated from the fluid by a solid wall, compressed till its pressure rises to p_0, then till it is liquefied under the pressure p_0, and finally till the fluid regains its original specific volume, when the pressure on the solution is brought back to its original amount. Further relations are derived from considering the quantities of heat necessary to make these changes isothermal. W. E. T.

912. *Conductivity of Salts and of Sodium dissolved in Liquid Ammonia.* **E. Legrand.** (Écl. Électr. 26. pp. 88–98, Jan. 19, 1901. Extracts from a thesis presented to the Faculty of Sciences of Paris, June 22, 1900.)—The method of determining the resistance depends on passing a current through the ammoniacal solution in series with a megohm resistance and comparing the p.d. at the terminals of the resistance with that near the two electrodes of the electrolytic cell; for the latter calomel electrodes were used with alcohol in place of water to prevent freezing. The electrolyte was cooled by adding solid carbon dioxide to a bath of acetone.

Experiments were made with twenty-three different salts, especially the chlorides, iodides, and nitrates. The resistances of these solutions show positive temperature-coefficients, similar in magnitude to those observed with aqueous solutions at about 51°. The molecular conductivities do not, however, show any tendency to reach a limiting value as the dilution increases, and cannot be represented as the sum of two quantities representing the conductivity of two ions. Values are also given of the conductivity at — 30° of mixtures of ammonia and water in different proportions.

Solutions of sodium in liquid ammonia conduct without any marked deposition on the electrodes, without liberation of gas, and with only slight signs of polarisation; the conductivity increases with the temperature, however, and the conduction is therefore probably electrolytic.

No simple relationship could be traced between the conductivity of the solutions and the viscosity of the solvent. T. M. L.

913. *Conductivities of Aqueous Solutions of Alkali Chlorides and Nitrates.* **F. Kohlrausch** and **M. E. Maltby.** (Phys. Tech. Reichsanstalt, Wiss. Abh. 3. pp. 155–227, 1900.)—This is the official publication by the Reichsanstalt of the research of which a preliminary report has already been given. [See Abstract No. 250 (1900).] The conductivities here determined will serve as standard, since every possible source of error has been allowed for or eliminated—

EQUIVALENT-CONDUCTIVITY AT 18°.

m gr-Equiv. Litre.	KCl	NaCl	LiCl	KNO$_3$	NaNO$_3$	LiNO$_3$	*v* Litre gr-Equiv.
0·0001	129·07	108·10	98·14	125·50	104·55	94·46	10,000
0·0002	128·77	107·82	97·85	125·18	104·19	94·15	5,000
0·0005	128·11	107·18	97·19	124·44	103·53	93·52	2,000
0·001	127·34	106·49	96·52	123.65	102·85	92·87	1,000
0·002	126·31	105·55	95·62	122·60	101·89	91·97	500
0·005	124·41	103·78	93·92	120·47	100·06	90·33	200
0·01	122·43	101·95	92·14	118·19	98·16	88·61	100
0·02	119·96	99·62	89·91	115·21	95·66	86·41	50
0·05	115·75	95·71	86·12	109·86	91·43	82·72	20
0·1	112·03	92·02	82·42	104·79	87·24	79.19	10
0·2	107·96	87·73	77·93	98·74	82·28	75·01	5
0·5	102·41	80·94	70·71	89·24	74·05	67·98	2
1	98·27	74·35	63·36	80·46	65·86	60·77	1
2	92·6	64·8	53·1	69·4	54·5		$\frac{1}{2}$
3	88·3	56·5	45·3	(61·3)	46·0		$\frac{1}{3}$
5		42·7	33·3				$\frac{1}{5}$
10			11·3				$\frac{1}{10}$

These figures are also represented graphically in the paper, the abscissæ being the cube root of the concentration, *i.e.*, the linear-concentration, and the ordinates being the equivalent-conductivities. The form of these curves for low concentration approaches that of a parabola. The different equations which have been proposed for this part of the curve are discussed. J. B. H.

914. *Effect of Potassium Chromate in Diminishing Kathodic Depolarisation.* **E. Müller.** (Zeitschr. Elektrochem. 7. pp. 398–405, Jan. 3, 1901. From the Zeitschr. Anorg. Chem. 26. 1, with alterations.)—The author has observed previously [see Abstract No. 1408 (1899)] that in the electrolytic production of chlorate by the electrolysis of alkaline chlorides, the reduction at the kathode of the hypochlorite produced at the anode is greatly diminished, and hence the output of chlorate greatly increased, by the addition of small quantities of alkaline chromate. In the present paper the author examines various hypotheses whereby this effect may be explained, and arrives at the conclusion that a thin layer of a compound of chromium is produced on the kathode at a certain kathodic potential, and that this layer acts as a diaphragm and causes the liberation of free hydrogen, whereby the reducing action of the latter is greatly diminished. Various solutions (sodium iodate, sodium iodate and sulphate, potassium nitrate, &c.) were electrolysed, with and without addition of chromate, and the percentage reduction determined by comparing the volume of hydrogen liberated at the kathode with that liberated in a hydrogen voltameter in series. The chromium compound produced at the kathode in solutions which are acid, or which contain an oxidising agent (such as hypochlorite), is considered to be chromic chromate; in other cases, hydrated chromic oxide. F. G. D.

915. *Polarisation with Alternating Currents.* **F. Oliveri.** (Phys. Zeitschr. 2. pp. 225–227, Jan. 12, 1901.)—If a voltameter be inserted in a circuit carrying an alternating current, then during each half-period one of three conditions must exist in the voltameter: (1) Only small polarisation may be produced; (2) The polarisation may be almost a maximum; (3) The electrodes may be saturated and electrolysis take place.

By using a Joubert arrangement of momentary contact for measuring the polarisation, the author, by varying the period of alternation, has experimentally proved the existence of these three conditions and finds that a voltameter, in the case when the polarisation is small, acts like a condenser.

No experimental data are given in this paper, which is itself an Abstract of the original paper (N. Cimento, 12. pp. 141–155, Sept.–Oct., 1900).

J. B. H.

916. *Electrolytic Analysis.* **A. Hollard.** (Écl. Électr. 26. pp. 165–166, Feb. 2, 1901.)—With reference to Ost and Klapproth's experiments on the estimation of antimony, the author remarks that the solution of the deposited metal by the polysulphides formed is only noticed when Classen's capsule is employed, and may be prevented by the use of Luckow's cone or of the electrolytic cell formerly described by the author. Another inconvenience attending the use of sodium sulphide is that small quantities of copper are dissolved by it, and deposited along with the antimony; this is prevented by adding potassium cyanide. In the presence of tin a large excess of sodium sulphide is necessary. N. L.

917. *Electrolytic Analysis.* **G. Arth.** (Écl. Électr. 26. pp. 129-131, Jan. 26, 1901.)—In the estimation of antimony by Classen's process the increasing amount of polysulphide lowers the voltage and causes a part of the deposited metal to be redissolved. Ost and Klapproth have sought to remove this defect by the use of a diaphragm. This latter has the form of a basin of porous porcelain which separates the platinum anode from the outer platinum dish which forms the kathode. If the solution of the sulphosalt of antimony containing excess of sodium sulphide is placed in both the anode and kathode compartments, the metal in the latter is completely precipitated, whilst that in the former remains in solution. When the antimony is introduced into the kathode space only, it is entirely removed from the solution, provided the sodium sulphide is sufficiently in excess and the voltage consequently low; if these conditions are not fulfilled, a little antimony sulphide is deposited on the anode. If the metallic solution is placed in the anode compartment only, the metal is not deposited on the kathode, but the sulphide is formed at the anode. From these results it is concluded that the e.m.f. depends almost entirely on the amount of sodium sulphide present; this first undergoes electrolysis, and the deposition of antimony is due to a secondary reaction. Antimony ions take no part in the process, and it is only under certain conditions, as stated above, that it passes through the diaphragm in the form of the complex ion SbS_4. In the electrolysis of sodium sulphide solution alone, hydrogen is evolved at the kathode in theoretical quantity, whilst if antimony is added a portion of the hydrogen is replaced by an equivalent quantity of the metal. Oxygen is formed at the anode, but is at once absorbed by the sodium sulphide with the formation of polysulphide and thiosulphate.

The author also describes the experiments of Kahlenberg [Abstract No. 2070 (1900)] on the electrolytic deposition of metals from non-aqueous solutions, and adds some remarks on the various attempts which have been made to substitute other metals for the costly platinum in electrolytic apparatus.

N. L.

918. *Electrolysis of a Mixture of Copper Sulphate and Sulphuric Acid.* **H. J. S. Sand.** (Phil. Mag. 1. pp. 45-79, Jan., 1901. Paper read before the Physical Society of London.)—This paper forms a valuable addition to our literature, both theoretical and experimental, dealing with the electrolysis of mixtures.

From theoretical considerations we are led to believe that hydrogen will not be given off from an acid solution of copper sulphate until the concentration of the copper has practically fallen to zero at the electrode. Experiment shows that hydrogen is liberated from a not too concentrated acid solution of copper sulphate by comparatively low current densities. It might be supposed that diffusion of the copper sulphate in the liquid would effectually hinder its concentration from going down to zero at the electrode with the rapidity which the experiments require to justify the theory, but in this paper the author shows that this is not the case.

The first part of the paper is theoretical, containing a mathematical deduction of an expression for the concentration at the electrode in a solution of a single salt from which the metal is being deposited under the conditions, (1) that the solution is contained in a cylindrical vessel bounded by the electrode; (2) that no convection currents occur, and (3) that the diffusion of the salt obeys Fick's law and its transport values are constant. The formula obtained can be made the basis of a method for roughly determining diffusion coefficients.

In the case of mixtures, it is possible to arrive at limits for the concentration, and it has been experimentally proved by the author (1) that hydrogen always appears at the electrode in an acid solution of copper sulphate in which no currents of liquid are flowing, between the limits of time calculated for the concentration to fall to zero; and (2) that the time when it appears differs only slightly from that calculated from the following equation—

$$c = c_0 - \frac{1{\cdot}1284}{96540} i(1 - n_c)\sqrt{\frac{t}{K}}$$

where c and c_0 are the concentrations at times t and 0, i being the current density in amperes per sq. cm., n_c being the transport value of the kation Cu in the solution and K being the diffusion coefficient of the salt.

The great part played by convection-currents in determining the ratio of the two constituents given off at the electrode of an acid copper sulphate solution is experimentally proved, effective stirring in one case causing the disappearance of hydrogen where it would otherwise have presented over 60 per cent. of the equivalents carrying the current from the solution to the electrode.

The paper contains many tables of experimental results and a description of several forms of apparatus employed. J. B. H.

919. *Laboratory Electric Furnaces.* **C. L. Norton.** (Elect. World and Engineer, 36. pp. 951–952, Dec. 22, 1900.)—The author gives a useful description of furnaces which he has used for laboratory work and temperatures ranging up to 2,000° C. One of these is made by winding 15 feet of No. 28 B. & S. platinum wire round an ordinary porous pot, as used for batteries. The pot is painted with magnesium carbonate to prevent slagging of the wire. The wire is annealed and crinkled to allow for shrinkage before winding on, and is fixed by coating with a paste of magnesium carbonate. Such a furnace when packed with insulating material requires 3 amperes at 220 volts for a bright red heat. A furnace for higher temperatures can be made with carbon as the conductor. W. R. C.

920. *Electrical Bleaching Apparatus.* **V. Engelhardt.** (Zeitschr. Elektrochem. 7. pp. 390–396, Jan. 3, 1900.) Reply by **F. Oettel.** (Zeitschr. Elektrochem. 7. pp. 449–451, Jan. 31, 1901.) The first paper is a criticism of F. Oettel's paper on the Haas and Oettel apparatus [see Abstract No. 537 (1901)]. Engelhardt finds fault with the manner in which Oettel compares the cost of working, plant, and efficiency of his own apparatus with the one invented by Kellner. The conclusion arrived at is that the Kellner apparatus in every point is superior to the Oettel apparatus. A number of comparative tables are given proving this. The second paper is Oettel's reply to the remarks made in the previous Abstract, in which the author wishes to prove that for the same output of chlorine his apparatus is still cheaper. Reference as to the life of the carbon plates as compared with the platinum-iridium wire gauze electrodes used by Kellner is also made. The effect of various concentrations and current densities is discussed. O. J. S.

921. *Present Position of Electrolytic Refining in U.S.A.* **T. Ulke.** (Elect. Rev. N.Y. 38. p. 85, Jan. 12, and pp. 101–103, Jan. 19, 1901.)—This article deals with the progress made in the electrolytic refining industry in U.S.A. during recent years. The number of electrolytic copper refineries is now eleven, and the present daily output of these refineries is estimated to be 579 tons. The slimes from the copper refining vats are treated for the extraction of their silver and gold, and are stated to yield 19,400,000 oz. silver and 174,000 oz. gold per annum. The Raritan Copper Refinery at Perth-Amboy is now the largest in the country, and has an output of 150 tons copper per day. At this refinery automatic machinery is used for moulding the anodes, and refining costs have now been reduced to under $8 per ton of anode copper. The parting of doré silver by the Molbuis process is carried on at three works, the largest of them being at Perth-Amboy. The daily output of the three refineries is estimated to be 160,000 oz. silver, and the refining charges do not amount to more than 20–30 cents per 100 oz. doré silver. The electrolytic refining of gold bullion is carried on at one refinery, namely, that of the U.S. mint at Philadelphia. The process used is that of Wohlwill, and the estimated daily output is 1,000 oz. J. B. C. K.

922. *Electrolytic Copper Refining Plant at Anaconda.* (Elect. World and Engineer, 37. pp. 186–187, Feb. 2, 1901.)—Details are given of the Anaconda refining plant. The raw copper comes from the smelters, thirty-two miles distant, in the form of anode plates, testing 99·6 per cent. of purity. The refining is carried out in 1,400 lead-lined vats, each vat measuring 8 × 5 × 3½ feet deep, and holding 4,000 litres of copper sulphate solution. This solution is circulated by means of pumps continually through the vats, and is kept warm by means of special heating vats. The success of the electrolytic process largely depends upon maintaining the electrolyte in proper condition and at a definite strength. This is checked by means of daily chemical tests. The vats are run in series of 200, the positive bus-bars of one vat being continued as negative bus-bars over the next vat in the series. Each vat contains 19 sets of anode plates and 20 sets of kathode plates, and requires an e.m.f. of 0·3 volt for a current of 4,000 amperes. The current density equals 18 amperes per square foot of anode area, and 210 lbs. copper are deposited per day of 24 hours. The electrodes are placed 2 inches apart, and the vat when charged contains 8,200 lbs. of anode copper. The anodes are renewed every 34 days. The kathode sheets are made by depositing copper electrolytically upon copper sheets coated with graphite and paraffin. These sheets at the end of 24 hours are stripped from the backing and used as kathodes in the refining vats. [For details of the generating machinery see Abstract No. 549 (1900).] J. B. C. K.

923. *Electrolytic Separation of the Alkaline Metals from their Molten Chlorides.* **A. Fischer.** (Zeitschr. Elektrochem. 7. pp. 349–354, 1900.)—In this paper the work done by Grabau and Borchers is first referred to and reasons given why the apparatus constructed by these investigators did not altogether give satisfactory results. In order to study the causes preventing good yields, the author first electrolysed a mixture of molten chlorides of potassium and sodium, using the current itself for keeping the electrolyte fused, employing current densities varying from 5 to 10 amperes per sq. cm. No diaphragm or partition was employed, thus enabling the investigator to closely follow the evolution of the chlorine and sodium. The carbon anode and iron kathode were first brought into close contact, and as the surrounding salt melted the distance of the two was increased, thus forming a pool of well fused electrolyte round the electrodes. The manner in which the two component elements were set free may be seen from the drawing, as indicated by the arrows and dotted lines.

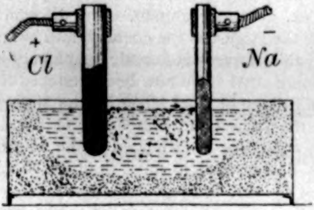


FIG. 1.

Based on these observations the author made a number of differently constructed cells, surrounding the kathode by an inverted metal bell, the immersed edges of which were kept cool by solidified salt, as the result of using a species of water jacket. It was, however, found that this device did not give satisfactory results, as the crust fused or detached itself after a short time, and the metallic bell became part of the kathode, thus interfering with the operation.

The final form of apparatus found to be most suitable is the one shown in the accompanying illustration.

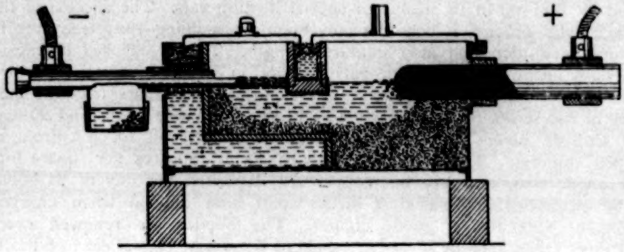


FIG. 2.

The cell consists of a rectangular box, made of sheet iron, having an iron water-jacketed portion in the centre dipping into the electrolyte surrounded by marble for the purpose of exposing no metallic surfaces. The kathodic portion of the apparatus is lined with marble and is water-cooled, which was found to answer the purpose well. The kathode itself consists of a metallic tube just resting horizontally on the surface of the molten electrolyte, thus serving at the same time as an exit pipe for the sodium formed.

Although this form of cell answered well on the whole, it was found that owing to a quantity of liquid sodium, which necessarily must be in the kathode tube, the current density was very much reduced, giving rise to decrease of temperature, and consequently non-fluidity of the electrolyte.

O. J. S.

REFERENCES.

924. *Electrical Energy Direct from Carbon.* **A. E. Kennelly.** (Elect. World and Engineer, 37. pp. 22–24, Jan. 5, 1901.)—A brief review of this subject.

W. R. C.

925. *Significance of Crystalline Form.* **W. F. C. Morsell.** (Frank. Inst., Journ. 150. pp. 441–460, Dec., 1900.)—This paper contains a discussion of the causes underlying the crystalline form of chemical compounds, and does not admit of a satisfactory Abstract. T. H. P

926. *Sterilisation of Water by Ozone.* **Abraham.** (Soc. Int. Élect., Bull. 17. pp. 414–433, Nov., 1900.)—A memoir reviewing the whole subject of water sterilisation, with a detailed description of the development of the various processes and methods of treatment by ozone. The Siemens and Halske, Tindal and Schneller, and Marmier and Abraham ozonisers are described, and the installation of the latter at Emmnerin for treatment of the Lille water supply is particularly dealt with. This has already been noticed [Abstracts Nos. 1755 and 1756 (1899)], but the memoir of the author adds to the previous information by the inclusion of diagrams and plans of the plant and machinery. J. B. C. K.

927. *Osmosis.* **J. Perrin.** (International Physical Congress at Paris, Report, 1. pp. 531–545, 1900.)—This is a short but exceedingly clear presentment of the outlines of our knowledge of this subject. The employment in gases and in liquids of semi-permeable diaphragms, whether natural or artificial, their mode of action as explained by Nernst, their theoretical importance and the part they play in reversible transformations, are all considered. R. E. B.

928. *Mixtures.* **J. D. van der Waals.** (International Physical Congress at Paris, Report, 1. pp. 583–614, 1900.)—This is a *résumé* of the author's theory of mixtures, of the results to which it leads, and of the experimental confirmation it has received. Chief consideration is given to mixtures of normal substances, *i.e.*, of substances the molecules of which are invariable, the report being divided into the following heads :—Homogeneous phases, coexistent phases (the differential equation for which is given and discussed as to its form and results in particular cases), critical phenomena of a mixture, retrograde condensation, critical curves : but a short discussion of mixtures of abnormal substances (of which one of the chief is water) is also given. Some of the ideas expressed in the report (principally in the part relating to mixtures of abnormal substances) are not unassailable ; but the author thinks it proper to indicate points that need examination and not merely to record what is definitely known. R. E. B.

929. *Solubility of Salts in Water.* **R. Dietz, R. Funk, J. v. Wrochem,** and **F. Mylius.** (Phys. Tech. Reichsanstalt, Wiss. Abh. 3. pp. 425–477, 1900.)—This paper, which does not admit of satisfactory abstraction, contains the results of measurements of the solubility in water of the halogen salts of zinc and cadmium, the nitrates of the zinc-iron group, cadmium sulphate, magnesium and calcium iodates, the sodium salts of chromic acid and calcium chromate. The various hydrates formed by each salt are given and solubility tables constructed so as to show (1) the concentration of the saturated solution in parts by weight, (2) the number of molecules of water per molecule of salt, and (3) the number of molecules of salt per 100 molecules of water. The solubility curves for the different hydrates are shown, and in some cases crystallographic data are given. T. H. P.

930. *Standard Cells.* **W. Jaeger.** (Centralblatt f. Accumulatoren- u. Elemententk. 2. pp. 1–4, Jan. 1 ; and pp. 23–24, Jan. 15, 1901.)—These papers conclude a series by the same author dealing with standard cells [see Abstract No. 2044 (1900)]. The author deals with the thermodynamics of the Cadmium cell and of the Clark cell, both when containing hepta- and hexa-hydrates of zinc sulphate, and gives an epitome of E. Cohen's paper on the same subject [Abstract No. 2064 (1900)]. In the concluding paper the author deals with the changes noticed at about 0° C. in the e.m.f. of the Cadmium cell containing a 14·3 per cent. cadmium amalgam [see Abstracts Nos. 181 and 419 (1901)]. J. B. H.

931. *Electrolytic Solution-Pressure.* **R. A. Lehfeldt.** (Zeitschr. Phys. Chem. 35. p. 369, Nov. 2, 1900.)—In reply to F. Krüger's criticisms (Zeitschr. Phys. Chem. 35. pp. 18–22, Oct. 5, 1900) on his paper [see Abstract No. 254 (1900)], the author points out that these are partly based on a misunderstanding caused by a misprint, and adheres to his conception of the meaning of Nernst's theory.
F. G. D.

932. *Fusion and Crystallisation.* **B. Weinberg.** (International Physical Congress at Paris, Report, 1. pp. 449–463, 1900.)—A *résumé* of Tammann's researches and conclusions on phenomena of fusion and crystallisation, and their bearing on the alleged continuity of the liquid and solid states. [See Abstracts Nos. 1 and 1263 (1898); 145, 326, 1111, 1150, and 1693 (1899); 1042 and 1659 (1900); 73 (1901).]
N. L.

933. *Crystallisation at Constant Temperature.* **J. H. van't Hoff.** (International Physical Congress at Paris, Report, 1. pp. 464–477, 1900.)—A summary of researches already published on the crystallisation of saline solutions and the theory of the formation of maritime salt deposits. [See Abstracts Nos. 1939 (1899); 226, 1114, and 1879 (1900).] N. L.

934. *Electro-chemical Equivalents of Silver, Copper, and Water.* **A. Leduc.** (International Physical Congress at Paris, Report, 2. pp. 440–459, 1900.)—The author discusses the results of the measurement of these quantities by different investigators, and in the case of silver, the influence exerted by the temperature, concentration of solution, &c., on the result. T. H. P.

935. *On some of the less well-known Carbides, Borides, and Silicides.* **R. S. Hutton.** (Electro-Chemist, 1. pp. 4–6, Jan., 1901.)—A general review of the subject. W. G. M.

936. *Vapour-Pressure of Binary Mixtures.* **P. Kohnstamm.** (Zeitschr. Phys. Chem. 36. pp. 41–62, Jan. 22, 1901.)—Recent views on the vapour-pressures of binary mixtures are discussed in the light of the theory of van der Waals, for whom the author claims not only priority in the discovery of the character of vapour-pressure curves, but also an avoidance of errors into which his successors, who seem to be ignorant of his work, have fallen. As regards the former point he shows that certain results found by others for dilute solutions are obtainable in certain ways from van der Waals' more general formulæ, and he exhibits the divergence of these results from each other and from the truth as arising from differences in their underlying assumptions and consequently in their differing conditions of validity. Some of Ostwald's assumptions and some of the reasoning founded upon them are finally submitted to adverse criticism. R. E. B.

937. *Equilibrium of Chemical Systems.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 21–65, Jan., 1901.)—This article is a translation of the more important parts of a thesis presented to the Faculty of Sciences of Bordeaux in April, 1900. It is divided into three chapters. In chapter I., entitled The Equilibrium of Heterogeneous Systems, the author, following Gibbs and Duhem, investigates and establishes the phase-law of Gibbs. In chapter II., entitled Indifferent Points, the author extends Duhem's theory to multivariant systems (an "indifferent point" occurs when the masses of the independent components are so chosen that the system behaves like a univariant system, *i.e.*, has one degree of internal freedom). In the third and last chapter, entitled The Displacement of Equilibrium, the investigation proceeds on the lines laid down by Planck, and the theorems associated with the names of Clapeyron, Gibbs and Konowalow, Le Châtelier, and van't Hoff are deduced. The paper cannot fail to be of interest to those who are desirous of studying the writings of Gibbs, Duhem, and Planck, even though it contains little that is essentially new. F. G. D.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

938. *Results of Superheating on the "Inchdune" and "Inchmarlo."* (Engineering, 71. p. 9, Jan. 4; and pp. 71–74, Jan. 18, 1901.)—The interest attending this plant lies in the use of superheated steam, and the extremely economical results obtained. The steam was superheated to a temperature approaching 500° F., and the coal consumption was only 0·97 lb. per i.h.p. per hour, or one ton of cargo was carried one nautical mile for about one-third of an ounce of coal.

The engine is of the five-cylinder quadruple expansion type, with all cylinders jacketed except the h.p. Boilers are single ended ordinary Scotch type, to carry 267 lbs. per square in. In the uptake is fitted the superheater, which consists of nests of wavy tubes, the steam entering at the top and leaving at the bottom. The furnace gases, after passing through the superheater, also pass through an air heater, where they are used to heat the air passing to the furnace on Ellis and Eaves' forced draught principle. The feed water is heated by two feed heaters and purified by two feed filters, great care being taken to eliminate all air from the feed water. The feed enters the boiler at temperatures varying between 310° F. and 370° F., and the funnel gases were cooled down to 319° F. in the fan. L. S. R.

GAS AND OIL ENGINES.

939. *New Principle in Gas Engine Design.* **C. E. Sargent.** (Mech. Eng. 6. pp. 857–860, 1900; and 7. pp. 29–32, Jan. 5, 1901. Paper read before the American Society of Mechanical Engineers, N.Y., Dec., 1900.) — The disadvantages of the modern gas engine, working on the Beau de Rochas or Otto cycle, are first considered. In a single-acting cylinder, only one impulse being obtained for every two revolutions of the crank-shaft, the working parts must be as heavy and strong for the three other strokes as for the working one, and the engine four times as heavy per h.p. as with an impulse every stroke. In order to improve the regulation of speed two or more cylinders are used. With a hit-and-miss governor there is good economy, because the compression is uniform, but the angular velocity is always increasing and decreasing. By throttling the admission of the fresh charge, and thus lowering the compression and the mean effective pressure, better regulation is obtained at the expense of the thermal efficiency. The high pressure and temperature when the exhaust valve opens are sources of loss. In a 125-h.p. engine a terminal pressure of 40 lbs. to 50 lbs. (absolute) requires a lifting force of more than a ton to open the exhaust valve, and mufflers are needed to deaden the "bark" of the exhaust. The loss of heat to the water jacket depends on the ratio of the volume of the explosive mixture to the surface which confines it, on the piston speed, and on the average temperature of the burning gases. The lower the terminal temperature, other things being equal, the lower the mean temperature, and less heat will be lost to the water jacket and exhaust. The smaller the cooling surface of cylinder walls, and the higher the speed of piston, the less heat will go into the water jacket and more into work. High speed of piston is essential for economy.

The prime object in the new design is to get more complete expansion of the gases during the working stroke, and the essential feature is to cut off the admission of the fresh charge about mid-stroke, or earlier when governing.

Fig. 1 is an indicator diagram taken from one end of a cylinder of the engine, and Fig. 2 a light spring diagram taken at the same time; *a b* is the atmospheric line, and represents the length of stroke. During the travel of the piston from *a* towards *b*, the fresh charge of gas and air is admitted to *e*, when the admission is cut off and the pressure drops to *c* at the end of the stroke. There is no loss in rarefying the fresh charge from *e* to *c*, since the work is given back to the piston as it returns; and compression above the atmosphere begins at *e* and continues to *d*, the point of ignition. Expansion takes place to *b* when the exhaust valve opens, and the pressure is slightly above atmospheric.

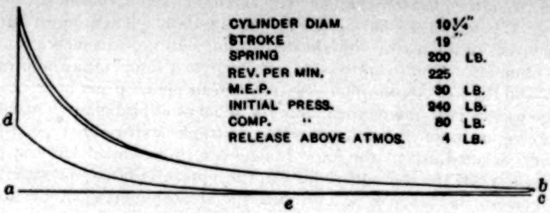


FIG. 1.

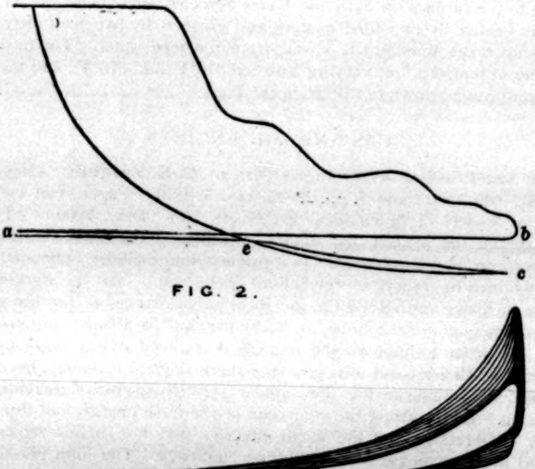
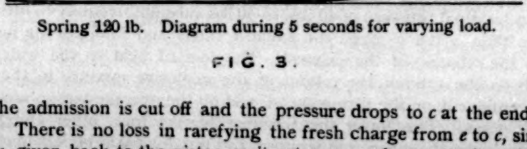


FIG. 2.



Spring 120 lb. Diagram during 5 seconds for varying load.

FIG. 3.

If the highest compression permissible at full power is obtained with cut-off at mid-stroke, then by making the governor cut off the admission earlier, and also ignite earlier as the speed increases, the pressure is always greatest at the beginning of the stroke (Fig. 8), and the efficiency for light loads should be higher than is usually obtained by throttling the charge, as there is no loss by wire-drawing or by late ignitions. The advantages claimed over the ordinary gas engine are:—(1) At full load 20 to 25 per cent. more heat is turned into work for the same amount of fuel. (2) A noiseless exhaust, doing away with mufflers (silencers), whilst the reduced pressure on the exhaust valve takes a great strain off the side-shaft in opening it. (3) The average temperature of the cylinder is reduced, avoiding premature ignition, and making possible the use of the piston-rod running through water-jacketed stuffing boxes in double-acting tandem cylinders. Therefore, an impulse is obtained every stroke as well as compression to absorb the inertia of the moving parts. (4) Regulation of speed equal to that of the steam engine. (5) For starting, by moving a lever, the valve mechanism can be changed to have ignition at the point of admission closure or cut-off *e*; and the exhaust opens at the end of the stroke *b*, and remains open during the back stroke of the piston. The same Lenoir cycle takes place at the other end of the cylinder. Otherwise compressed air could be used to get up speed, with a fixed cut-off at half stroke.

Description of Engine.—Side elevations and vertical sections are given of a 75-h.p. horizontal engine, with two double-acting tandem cylinders. The frame is of the self-oiling enclosed type, keeping the oil in and dust out, with bored guides and side-doors, giving access to crosshead and stuffing box. The side-shaft is driven by worm gears at half the speed of crank-shaft. The valve cams and electric igniters, one for each of the four explosion chambers, are keyed to this shaft, 90° apart, so that one end of one cylinder is always giving an impulse stroke, while the three other ends are exhausting, compressing, or drawing in a fresh charge respectively. The worm gears driving the cam-shaft run in a tight-fitting case, into which the oil flows from the basin under the crank-shaft, and is carried up in the spaces between the teeth, and is forced by this ideal pump through a system of circulating pipes to the different sight-feed oilers to the engine bearings. The oil flows by gravity through the strainer back to the settling chamber in the crank case basin. The electric igniter is so placed in each cylinder that a combustible mixture, free from exhaust, always surrounds it, insuring proper ignition of the fresh charge, even at atmospheric pressure.

When the speed goes above the normal, the governor gear makes the cut-off earlier, and less gas and air are admitted to the cylinder; also the time of every other operation controlled by the cams is advanced.

As the mean effective pressure of an engine utilising only about two-fifths of a cylinder full of combustible mixture for the average load is about 60 per cent. of that of the ordinary gas engine, the cylinder capacity of this engine with greater expansion must be nearly twice that of the ordinary gas engine cylinder for the same power developed; yet the same could be said of a steam engine utilising the expansion of the steam compared to one without cut-off. The weight for a given output is reduced by the double-acting cylinders, and the engine may be worked with a greater variation of load than the single-acting engine without much loss in efficiency. With a fixed point of ignition and a slower inflammation as the load decreases, a limit to the piston-speed is reached, about 600 feet per minute; whereas by making the point of ignition earlier in this engine, the piston-speed is 700 feet per minute.

W. R.

940. *Test of Diesel Motor.* (Automotor Journal, 4. pp. 593–596, 1900. Paper read before the Congrès de Mécanique Appliquée, Paris, 1900, by **Diesel.**)—The paper describes the principle and working of the Diesel motor [Abstract No. 974 (1898)], and gives the following figures of a test at full load, when supplied with Russian naphtha and Roumanian petroleum, both rated at 10,000 calories per kilo; the motor showed a consumption of 208 grammes per b.h.p. hour, with a thermal efficiency of 43·6 per cent. The efficiency reached 52·8 per cent. at 6·8 b.h.p. by reason of the excess of air, the combustion curve being then nearer the isothermal. With illuminating gas of 5,000 calories per cubic metre, the thermal efficiency was 36 per cent., and the consumption 470 litres per b.h.p. hour. The thermal efficiency of the Diesel motor is about double that of the ordinary oil engine, but its mechanical efficiency is low, being from 70–75 per cent. Ten indicator diagrams are given in the paper. G. H. B.

AUTOMOBILISM.[1]

941. *Automobilism.* (Automotor Journal, 4. pp. 596–598, Sept., 1900. Paper read at the Congrès de Mécanique Appliquée, Paris, 1900, by **Rochet, Cuenot,** and **Mesnager.**)—The paper is divided into three sections:—(1) Tractive efforts. (2) Existing motors. (3) Gearing, steering, &c. The tractive resistances are: (*a*) Road resistance, varying with the state of the road, the width and nature of tyres, and the diameter of the driving wheels. (*b*) Friction of the journals, which depends on the ratio between the diameters of the wheel and its journal, and also on a friction coefficient, varying with the lubricant. (*c*) Air resistance, calculated from the empirical formula,

$$\text{Resistance} = 0{\cdot}005V^2S \text{ kg. per sq. m.,}$$

where V is the speed in km. per hour and S is the cross-section of car in sq. m. The total tractive effort in kg. per kg. weight is given as

$$0{\cdot}033 + 0{\cdot}0006V \text{ with solid tyres,}$$
$$0{\cdot}025 + 0{\cdot}0004V \text{ with pneumatic tyres.}$$

Assuming that the mean gradient on an average run is 1 per cent., the tractive effort necessary to drive a ton at a speed of 10 km. per hour is 1·82 b.h.p. with solid tyres and 1·45 with pneumatic tyres.

A table is given of the different kinds of boilers used in steam vehicles, for solid and liquid fuel, showing the working pressure, the diameter of tubes, the heating surface, the weight, and the consumption. The steam engines are generally made compound above 15 b.h.p. The steam is usually superheated; its temperature in the Serpollet boilers is from 350° to 400° C., at pressures up to 255 lbs. per square inch. The speed of the motor varies from 300 to 800 r.p.m. The total efficiency in power available on the shaft is only about 6 per cent. of the calorific power of the fuel.

For oil engines the effective output is from 0·21 to 0·25 of the theoretical calorific power. Tables are given for steam and oil engines, showing the weight and consumption of various motors per b.h.p. on the shaft and on the wheel-rim. The description of driving and steering gears is abstracted briefly, and the paper concludes with a table of the distribution of weight in the different parts of steam, oil, and electric cars. G. H. B.

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[1] Electric Automobiles are described in the Section dealing with Electric Traction.

942. *Hult's Rotary Steam Engine.* **E. Dieudonné.** (Locomotion Automobile, 8. pp. 69–72, Jan. 31, 1901.)—In this motor the piston and the cylinder are both carried, eccentrically to one another in roller bearings, and the contact line between them can be maintained to an exact fit by means of an adjustment. The steam enters through a hollow shaft, and the abutment, which slides in the piston, is kept in contact with the cylinder wall by centrifugal force. Sectional drawings accompany the description, and the means of admitting the steam so as to work expansively is explained. The employment of the motor for automobile work is advocated, and it is stated that the steam consumption is about the same as that of the best reciprocating engines; a test with a 15-h.p. Hult motor showed a consumption of 17 kg. per effective h.p. hour.
A. G. N.

943. *Musker Steam Waggon.* (Automotor Journal, 5. pp. 161–166, Jan., 1901.) A fully illustrated description of all the mechanism employed upon the first steam lorry made by this firm. [See Abstract No. 902 (1900).]—The machinery is carried upon a separate underframe, which is suspended by spiral springs from, and between, the front and rear axles. A "flash" boiler is automatically supplied with kerosene, with the necessary air and with water, in fixed proportional quantities. A mechanical stoker which serves this purpose consists of a constantly running auxiliary engine, whose speed is automatically varied by the steam pressure generated. It drives a centrifugal fan, which is geared to a high rate of speed, and two oscillating valveless pumps, which work at half the engine speed; the ports of the pumps are opened and closed by their oscillating movement. The steam to this engine passes through one or both of two reducing valves, the one of which is set to 100 lbs. per square inch and the other to 50 lbs. per square inch. The lower pressure valve is always open, and allows the engine to run only sufficiently fast to nearly keep steam in the boiler when the waggon is standing. The higher pressure reducing valve is supplied with steam only when an automatically operated throttle valve is open. This throttle valve is normally held open by a spring, but is closed so soon as the boiler pressure reaches a certain limit. In this way the speed of the auxiliary engine is regulated by the boiler pressure and the boiler pressure is automatically kept constant in spite of variations of load on the main engines. Other automatic devices consist of two constant, though adjustable, by-passes, and of one automatically controlled by-pass. The former are placed in the delivery pipes of the oil and the water pumps; since they allow a certain quantity of the feeds to return to their respective supply tanks, they both admit of relative adjustments, and they ensure a slight excess of proportionate feed as the speed of the pumps increases. The automatic by-pass is placed in the water delivery pipe and it is operated by a brass rod which is enclosed in one of the live-steam pipes. The action of this device is such that, when the temperature of the steam rises, the rod expands and closes the by-pass, thereby causing more water to enter the boiler and the temperature of the steam to be decreased. The steam generator consists of three concentric tubular coils of solid weldless steel piping; about 270 feet are employed, and the tubes are 1$\frac{1}{16}$ inches diameter outside and $\frac{11}{16}$ inch inside. The coils are enclosed in an outside lagging of asbestos and sheet-iron and the ends of the two inner coils, furthest from the burner, are stopped with asbestos. The burner occupies one end of the generator, and the heat from it passes into the central space inside the coils; from there it finds its way between the turns of the two inner coils, and it passes out along the inner surface of the outside coil to the exhaust flue. The water is forced through the outer (or feed heater) coil towards the burner, through the intermediate coil from the burner and through the inner (or super-heating) coil towards the burner; the connections between coil and coil are all made at the cooler end of the generator. The burner is of cast iron, and consists of a ribbed chamber into which the air is forced, a second chamber into which it passes after being warmed, and into which the oil is delivered, a multitubular nozzle through which the combustible mixture passes and in which a sheet of wire gauze prevents back firing, and a central pipe which passes through the nozzle and which serves for preliminary lighting and for observation. An iron baffle is placed between the burner and the generator proper. For starting the furnace, methylated spirit is used to heat up the burner. The main engines have four vertical single-acting cylinders, 5¼-inch bore by 3-inch stroke. The power is transmitted by toothed gearing to a differential gear on a countershaft, and from the ends of this countershaft to large sprocket wheels on the rear wheels of the wagon, by Renolds' chains. Mushroom valves, operated by four eccentrics, control the passage of steam to and from the cylinders. The eccentrics are carried on a cranked valve-shaft, which slides longitudinally in its bearings, and which enables the cut-off to be varied from ¾ to ¼ in either direction of rotation. A double safety valve, in the steam pipe, is set to a pressure of 500 lbs. per square inch, and a throttle valve is provided under the control of the driver. The capacity of the water and oil pumps are proportioned in the ratio of 15 to 1, by weight. The boiler will evaporate about 17 lbs. of water from and at 212° F. with 1 lb. of ordinary petroleum. The waggon weighs 3¼ tons in working order (the tare is under 3 tons), and it will carry a load of 5 tons at a greater speed than 5 miles per hour. The platform is 17 feet long by 6 ft. 6 in. wide. The front wheels are 3 feet in diameter and the rear wheels are 3 ft. 3 in. in diameter; 5-in. tyres are fitted to all wheels. A. G. N.

944. *Kécheur Petrol Car.* **P. Sarrey.** (Locomotion Automobile, 8. pp. 6–8, Jan. 3, 1901.)—The author describes a light petrol car designed by A. Kécheur. The motor and speed-changing gear are the special features of interest. The motor is of 4 h.p. and has two horizontal cylinders mounted opposite one another, and having pistons coupled to a single-crank enclosed in an aluminium crank case. The cylinders and combustion and valve chambers are air cooled by means of numerous radiating ribs. The cylinder dimensions are 74 mm. bore × 85 mm. stroke; the diameters of the valves are 26 mm. for admission and 28 mm. for exhaust. A Longuemare carburettor and electric ignition are employed. In the speed-changing gear a spur pinion is mounted at the extremity of the crank-shaft, and in engagement with it is a second pinion mounted on a pin in a drum which may be turned on the engine-shaft to any desired angle, the pinions always remaining in engagement. At certain positions of the drum the satellite pinion engages with other pinions mounted on fixed pins, and these in turn engage with an internal toothed drum on a shaft from which the power is transmitted to the driving axle. In this manner any desired number of speeds (three forward and one reverse in the car illustrated) may be obtained. C. R. D'E.

945. *Lufbéry Motor Car.* **L. Baudry de Saunier.** (Locomotion Automobile, 8. pp. 53–58, Jan. 24, 1901.)—A fully illustrated description of a petrol-driven vehicle in the design of which many interesting departures from ordinary practice have been made. The chief feature is the transmission gear, which consists of a three-stepped pulley on the motor shaft, a single belt for taking the power to a similar pulley on a countershaft, epicyclic gearing inside the countershaft pulley and a clutch on this shaft. With these comparatively few parts no less than five different forward speeds and three in a reverse direction are obtained. The three fastest forward speeds result from changing the belt from one to another position on the stepped pulleys when the driven pulley is made rigid with the countershaft. By the introduction of the epicyclic train between this driven pulley and its shaft a reduction of the relative speed of the latter is brought about; the highest of the three resulting speeds being equal to the lowest of the three previous speeds, five different gear ratios are thus available. For reversing the vehicle the epicyclic train is moved into mesh with an externally toothed wheel instead of one internally toothed. In order to allow of the movement of the belt from one position to another the pulley faces are bevelled off at their edges, a jockey pulley having a wide range of motion is arranged so as to tighten or slacken the belt, and a special striking gear is fitted. The general arrangement of the vehicle consists of a double cylinder water-jacketed vertical motor fixed at the back of the frame, the countershaft above described placed transversely across the frame and forward of the rear-driving wheels, outside chains connecting the countershaft with each driving wheel and the usual steering gear in front. A. G. N.

946. *Gaillardet Automobiles.* (Locomotion Automobile, 8. pp. 38–42, Jan. 17, 1901.)—Either single-cylinder (6 h.p.) motors or double-cylinder (12 h.p.) motors are employed in the construction of the two types of petrol carriages made by Gaillardet. These motors are of the vertical water-cooled type and are fitted with a form of hit-and-miss governor acting upon the exhaust valves. Variations of speed between 600 and 1,600 r.p.m. are provided for, and either electric or tube ignition (or both) is used. The water tank is placed above the motor in order that natural circulation shall take place in the event of the pump failing to act, and fusible plugs are fitted in the cylinders in such a way that they will melt, and stop the motor, if the temperature were to rise above a safe limit. The motor is fixed in the front of the carriage, the power being transmitted from a wide pulley on the crankshaft to either of three pulleys on a countershaft, by a single belt. The countershaft is mounted in bearings which are pivotted about a second countershaft. The three pulleys are placed side by side and are all of the same size. The central pulley is loose, and those on either side are connected by toothed gearing of different ratios to a differential gear on the second countershaft. A reverse motion is obtained by means of an epicyclic train of wheels contained in the low speed pulley, and it is brought into play by means of a clutch. The precise design of this change-speed mechanism has been carefully considered with a view to the reduction of friction so far as possible; a sectional drawing is given with the description. Drawings of the motors, of the system of governing, and of the complete vehicle also accompany the article. A. G. N.

947. *Schaudel Motor Car.* (Horseless Age, 7. pp. 21–26, Dec. 19, 1900. From La France Automobile.)—This article describes a new French petrol car, the design of which embodies several excellent features. The engine, which is of the two-cylinder horizontal type, is located at the front of an underframe of angle steel filled in with wood, and slightly inclined so as to prevent the lubricating oil in the crank chamber from gaining access too freely to the cylinder bodies and so passing into the combustion chambers. The power is transmitted from the crank-shaft through a cone friction clutch to a chain gear which drives the first motion shaft of the change-speed gear located immediately in front of the back axle. This change gear is of the usual sliding side-contact spur-gear type, and gives four forward and one reverse speed; the final drive to the road wheels is by spur pinions engaging with internal toothed drums bolted to the wheel spokes. A feature of this arrangement of transmission gear is that none of the brakes operate through the chain drive, so that the car may be instantly controlled even if the chain should break.

The engine has been unusually well thought out. The two cylinders are placed side by side with pistons coupled to a single crank-shaft so that there is one working stroke every revolution. The cylinder bodies, explosion chambers, valve chambers, and water-jacket are all in one casting, the only detachable part being a cover which closes the end of the water-jacket, which is very simply held in place by two large nuts screwing over the ignition plug bosses at the ends of the explosion chambers. By removing this cover the water jacket may be easily inspected and cleaned out. Both admission and exhaust valves open direct into the explosion chambers, and are suitably proportioned to the volume of the cylinders. All the valves may be removed by releasing one nut which holds down a bridge-piece over the admission valve seatings. The exhaust valves are operated by rocking levers at the end of a longitudinal half-speed shaft which is driven from gear within the crank chamber. The governor is of the centrifugal type and mounted so that it forms part of the exhaust valve operating gear. A spring control to the governor gives a ready means of increasing or reducing the speed of the engine. To secure easy starting an arrangement is employed whereby the admission valves may be held open and the pressure of compression so reduced to any desired extent. Low tension magneto-electric ignition is employed, the magneto and the make-and-brake switches being operated from the half-speed shaft of the engine. The carburettor is a modified form of the usual float feed spray-making type. The steering is by a hand-wheel mounted on an inclined shaft and connected to the road-wheel pivots through a rack and pinion. Most of the controlling levers are mounted on the steering pillar below the hand-wheel. The general lines of the vehicle appear to be excellent, and the heavy parts are mostly at or near the level of the axles. The article is well illustrated. C. R. D'E.

948. *Theoretical Data for High-speed Explosion Motors.* **P. Colardeau.** (Génie Civil, 38. pp. 206–208, Jan. 26, 1901.)—The results obtained from tests made with some of the best-known petrol motors are used for deriving formulæ for the guidance of new manufacturers. These formulæ refer to dimensions of cylinders, powers developed, and to the question of piston speeds. After stating that the power is proportional to the cylinder diameter, the stroke, the number of revolutions per minute, and a coefficient K, the writer proceeds to consider the value of K. It depends on the mean pressure, on the fuel, on the system of cooling, on the arrangement of the valves, and it is not a constant. Curves of power developed and of the accompanying torque for various motor-speeds from zero upwards are plotted out, and these show that for values of Cn—stroke in decimeters $\times \frac{\text{revs. per min.}}{1{,}000}$ (which is equal to a piston speed of 3·33 metres per second)—between 0 and 1 the power developed increases with the speed, the torque remaining constant. For values of Cn between 1 and 1·2 the torque decreases, and the power does not therefore increase proportionately with the speed, although it does still increase. Above the value 1·2 for Cn, the power itself also decreases rapidly. In these experiments compressions varying between 2·5 and 4·0 kg. per sq. cm. were used, and the mean pressure was found to be sensibly the same. The $\frac{\text{stroke}}{\text{diameter}}$ of the motors tested varied from $\frac{100}{90}$ to $\frac{120}{130}$. In the accompanying table the actual values of Cn and of K (P = horse-power and A = cylinder diam.) are given for various motors; the writer recommends values for Cn of between 1·0 and 1·2, and he considers that K = 4 ought to be a maximum, and should in practice be taken at 3·6 to 3·7.

Motor.	Horse-power.	Number of Cylinders.	Power of each Cylinder.	Cylinder bore in mm.	Stroke in mm.	Revolutions n per minute.	Cn.	$K = \frac{P}{A^2Cn}$.
Benz	5·25	1	5·25	150	180	500	0·90	2·60
Daimler Levassor	2·50	2	1·25	72	126	750	0·94	2·62
Peugeot	4·90	2	2·45	84	126	750	0·94	2·70
A. Bollée	6·50	2	3·25	95	160	660	1·05	3·37
Y. 3 *bis*[1]	3·00	1	3·00	90	100	1,050	1·05	3·52
Y. 8[1]	2·50	1	2·50	84	100	1,000	1·00	3·56
Y. 4[1]	6·81	1	6·81	30	120	960	1·15	3·62
Y. 1[1]	7·50	2	3·75	90	120	950	1·14	4·14
Peugeot[2]	6·00	2	3·00	96	132	680	0·89	3·64
Mors[3]	16·00	4	4·00	96	140	725	1·02	4·27
Panhard[4]	12·00	4	3·00	90	130	700	0·91	4·07
A. Bollée[4]	9·50	2	4·75	110	160	660	1·05	3·70
Peugeot[2, 5]	3·40	2	1·70	72	108	900	0·97	3·34
Rochet Petit[5] ...	6·00	2	3·00	94	140	720	1·05	3·36
Brouhot[5]	7·00	2	3·50	90	160	650	1·04	4·25
Brouhot[5]	9·00	2	4·50	110	160	650	1·04	3·65
Bardon[5]	7·25	2	3·62	100	100	1,000	1·00	3·62
Pygmée[5]	8·00	2	4·00	110	150	650	0·98	3·40
Panhard[5]	8·00	4	2·00	80	120	700	0·84	3·72

[1] Personal experience of author.
[2] Concours des fiacres, 1898.
[3] Tour de France, 1898.
[4] Poids Lourds, 1899 and 1900.
[5] Concours de Tourisme, 1900.

The article concludes with a consideration of the various conditions under which these motors have to work when propelling automobiles, and when used with and without change-speed gearing, and with or without governors.

A. G. N.

949. *Lélang Change-speed Gear.* (Locomotion Automobile, 8. pp. 9–10, Jan. 3, 1901.)—In this device a toothed wheel upon the motor shaft gears with a similar wheel which is free to revolve upon its own axis. Both wheels are enclosed in a casing which is itself mounted about the motor-shaft, and from which the power is taken at varying speeds. The casing is so shaped that it forms passages for the circulation of a liquid with which it is filled. The normal action of the toothed wheels is to circulate this liquid through one of the passages, and under these free conditions the casing remains stationary. A valve is fitted in this passage, and it can be closed either partly or entirely at will. When completely shut, the circulation of the liquid is stopped, and the whole apparatus is then compelled to revolve with the motor-shaft. By regulating the degree to which the valve is opened, a progressive clutch action is obtained, and the speed of the casing can be varied from that of the motor to zero. A. G. N.

REFERENCES.

950. *Uniformity of Turning Moment in Steam Engines.* **Lorenz.** (Inst. Naval Architects, Trans. 42. pp. 175–179 ; Discussion, pp. 179–185, 1900.)—The author shows, by methods of harmonic analysis, that the best possible uniformity of turning moment, in a three- or four-crank engine, is not only compatible with the conditions for balancing, but is dependent on them. He gives a method by which, supposing the crank angles already definitely given by conditions for balancing, the necessary distribution of work between the cylinders so as to give the least variation of turning moment may be found. H. R. C.

951. *Balancing of Steam Engines.* **O. Schlick.** (Inst. Naval Architects, Trans. 42. pp. 135–154 ; Discussion, pp. 155–165, 1900.)—The author investigates mathematically the problem of balancing a four-crank engine, taking account of the obliquity of the connecting-rods. H. R. C.

952. *Lentz Engines.* **F. Freytag.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1449–1457, 1900.)—A full description, with several drawings, of the various types of engine manufactured under the Lentz patents by the Brünn Machine Company.

953. *Gehre's Steam Meter.* **L. C. Wolff.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1694–1697, 1900.)—This apparatus is intended to measure the amount of steam passing at any instant along a steam pipe, the amount being automatically recorded on a revolving drum.

954. *French Trials of Alcohol for Automobiles.* (Automotor Journal, 5. p. 173, Jan., 1901.)—See also Reference No. 437 (1901).

GENERAL ELECTRICAL ENGINEERING.

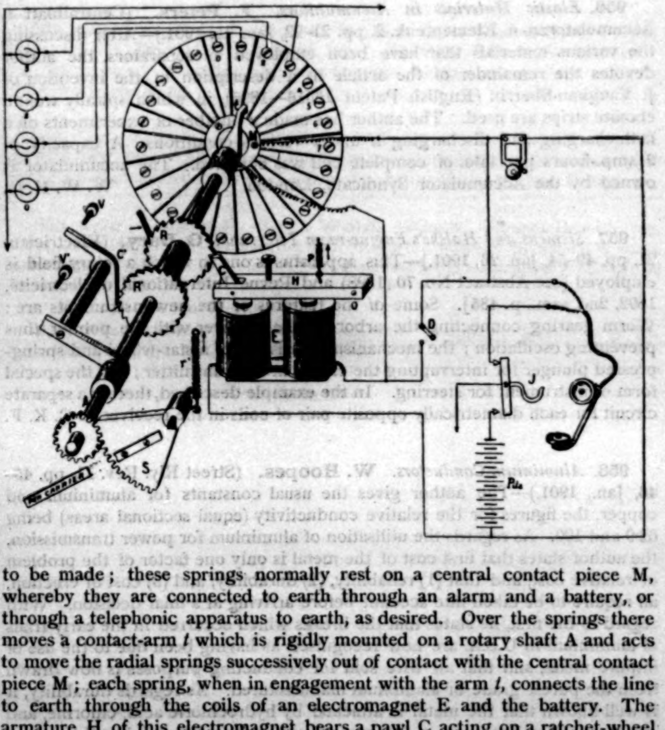
955. *Casting Accumulator Plates.* (Centralblatt f. Accumulatoren- u. Elementenk. 1. pp. 415–416, Dec. 15, 1900.)—The usual method of pouring the molten lead at 400–600° directly from a ladle into the mould has several objections. These are overcome by the process of E. Levermann (D.R.P. 111,758). The improvement consists in attaching to the mouth of the mould a specially designed enclosed chamber which enables the work of casting to be accelerated. W. W. H. G.

956. *Elastic Materials in Accumulators.* **F. Peters.** (Centralblatt f. Accumulatoren- u. Elementenk. 2. pp. 21–22, Jan. 15, 1901.)—After discussing the various materials that have been employed as separators. the author devotes the remainder of the article to a description of the invention of J. Vaughan-Sherrin (English Patent 16516—1896), in which spirally wound ebonite strips are used. The author has made a number of experiments on a cell, charging and discharging it under various conditions. A capacity of 9 amp.-hours per kilo. of complete cell was obtained. The accumulator is owned by the Accumulator Syndicate, London. W. W. H. G.

957. *Siemens and Halske's Engine-room Telegraph.* **G. Dary.** (Électricien, 21. pp. 49–54, Jan. 26, 1901.)—This apparatus is one in which a rotary field is employed [see Abstract No. 70 (1898) and Revue International d'Électricité, 1892, 2nd sem., p. 485]. Some of the features of the new instruments are: Worm gearing connecting the arbor of the receiver with the pointer, thus preventing oscillation; the mechanism consisting of a star-wheel and spring-pressed plunger for interrupting the circuit at the transmitter; and the special form of instrument for steering. In the example described, there is a separate circuit for each diametrically opposite pair of coils in the receiver. C. K. F.

958. *Aluminium Conductors.* **W. Hoopes.** (Street Rly. Rev. 11. pp. 45–46, Jan., 1901.)—The author gives the usual constants for aluminium and copper, the figures for the relative conductivity (equal sectional areas) being 62·9 and 100. As regards the utilisation of aluminium for power transmission, the author states that first cost of the metal is only one factor of the problem of relative cost, and that (1) reliability, (2) durability, and (3) cost of erection, all require to be taken into account before arriving at a final decision. With regard to the first, he states that the breaks which occurred in the early trials of aluminium in U.S.A. are now recognised as having been due to the use of impure metal, and that all wire sold for conducting purposes is now drawn from the purest grade of aluminium manufactured. As regards durability, it is well known that the metal is attacked by hydrochloric acid, chlorine, and caustic alkalies, but even in the case of atmospheres containing these compounds, oxidation of the metal will probably hinder disintegration. With regard to the third point, the cost of erecting aluminium should not be greater than that of erecting copper, for the metal is much lighter, and longer lengths of wire can be handled without difficulty. Fewer joints will also be required. Two recent orders for aluminium in connection with power schemes in U.S.A. have amounted to 1,000,000 lbs. and 250,000 lbs. respectively. J. B. C. K.

959. *The Pecquet Watchman's Control System.* **L. Montillot.** (Électricien, 20. pp. 371–373, Dec. 15, 1900.)—In this system there is a central control station which is connected by lines to the points at which the watchman has to call. At each of these points the line ends in a spring arranged opposite to another spring connected to earth, so that by inserting a plug bearing two contacts between the springs the watchman can connect the respective lines to earth through an alarm, or through a pair of telephones, as desired. At the central station, each line is connected to one of a series of springs arranged radially on an insulating frame in the order in which the calls are to be made; these springs normally rest on a central contact piece M, whereby they are connected to earth through an alarm and a battery, or through a telephonic apparatus to earth, as desired. Over the springs there moves a contact-arm *t* which is rigidly mounted on a rotary shaft A and acts to move the radial springs successively out of contact with the central contact piece M; each spring, when in engagement with the arm *t*, connects the line to earth through the coils of an electromagnet E and the battery. The armature H of this electromagnet bears a pawl C acting on a ratchet-wheel R which is rigidly connected by a sleeve N to a second ratchet wheel R^1 having its teeth arranged in the opposite direction and engaging a pawl C^1 mounted on an arm B^1 on the shaft A, so that the shaft will be rotated by the pawl C through an angle corresponding to one spring each time the electro-



magnet E is de-energised. The shaft also bears a pinion P engaging a toothed segmental wheel S having a pen which is in contact with a chart moved by clockwork. It will be seen that, as the watchman inserts his plug between the springs at the several calling points, the circuits will be closed and the armature H displaced to enable the ratchet-wheel R to be turned by the spring P when the circuit is broken on removing the plug. When all the stations have been visited, the pawl C^1 is tripped by the stop V^1, and the shaft A returned to its initial position by the spring r^1, the sleeve N bearing the ratchet-wheels R and R^1 meanwhile remaining stationary. By placing the plug a second time between the springs, the watchman can close the circuit of the bell at the central circuit through the plate M, since the arm B will have been moved on to the spring of the next call point. If the circuit be closed through the switch D, the watchman will hear the ringing on his alarm and thus be advised that he is to speak with the central station.

C. K. F.

960. *Electrical Apparatus in Coal-Mining.* **J. P. Jackson.** (Frank. Instit., Journ. 151. pp. 29–50, Jan., 1901.)—This is a paper broadly covering the ground of the application of electrical apparatus in coal-mining, and is of special interest in that it shows some of the actual difficulties which have occurred in practice under the conditions of installation-making, &c., current in America. It clearly shows that about 250 volts is the maximum safe pressure in mining, as both men and mules have been injured to a considerable extent with 500 volts. Some useful figures and data as to electric haulage by locomotives and the use of electric coal-cutters are given, and the author emphasises the necessity for electric plants being put in charge of persons with electrical knowledge, instead of as usual into the hands of a "bright young miner."

Ll. B. A.

961. *Tests of Electrical Hoists.* (Elect. Rev. 47. pp. 1023–1028, Dec. 28, 1900.)—The hoist tested was constructed to lift one ton at 40 feet per minute. It is driven at 850 revs. by a motor, which drives through steel cut gears, and is capable of taking 25 amperes at 220 volts. The cage, which is balanced by a cast-iron weight, is raised by a 2-inch rope. A complete table of results is given. A more detailed test on a larger lift is also given, and shows an excessive power consumption, which is attributed to over-heating of a worm wheel.

M. O'G.

962. *Winding of Spools.* **F. Claussen.** (Elektrotechn. Zeitschr. 21. p. 1055, 1900.)—In a letter to the editor the formulæ previously given by A. Löwit [Abstract No. 235 (1901)] are discussed and more complete ones proposed, in which the case of rectangular wire is included. The method of calculation is as follows:—

Let $d + \delta$ be the diameter of the covered circular wire, δ being the thickness of the insulation, $d_1 + \delta$ and $d_2 + \delta$ the dimensions of the cross-section of the rectangular wire. Then the areas will respectively be:—

$$q_1 = \frac{\pi}{4}(d+\delta)^2,$$

$$q_1 = (d_1+\delta)(d_2+\delta);$$

and if in either case—

$$\frac{q_1}{q} = y = \frac{\text{area of covered wire}}{\text{area of copper}},$$

then the total number, n, of the windings will be :—

$$n = \frac{l}{d_1 + \delta} \cdot \frac{h}{d_2 + \delta} = \frac{lh}{q_1} = \frac{lh}{yq},$$

where l is the length and h the depth of the winding. The resistance of the bobbin for each layer will be :—

$$w = \frac{us}{q},$$

in which $u =$ mean length of a turn and $s =$ the specific resistance of the wire, and the total resistance—

$$W = nw = \frac{lhus}{yq^2}.$$

We have also—

$$W = V/i,$$

V being the terminal voltage and i the current. Or,

$$\frac{V}{i} = \frac{lhus}{yq^2}.$$

The value of q is determined by—

$$q = \frac{Zsu}{V},$$

where Z is the number of ampere turns. For a bobbin of specified inner and outer diameter and with Z given, then hus/yq^2 is a constant, and—

$$V/i = l \, . \, \text{const.} = W,$$

or—

$$il = V/\text{const.} = \text{const.}$$

The value of l is next considered. The outer cooling surface is—

$$O = lD_a\pi,$$

D_a being the outer diameter of the winding,

and—

$$D_a\pi = u + h\pi\,;$$

hence—

$$O = l(u + h\pi).$$

Again—

$$O = i^2WZ_1,$$

where Z_1 is the number of square centimetres of surface allowed per watt spent in the coil.

Hence—

$$l(u + h\pi) = i^2WZ_1.$$

If—

$$\frac{hus}{yq^2} = k,$$

then—

$$V/i = W = lk.$$

Hence—

$$\frac{u + h\pi}{k} = i^2Z_1,$$

or—

$$i = \sqrt{\frac{u + h\pi}{kZ_1}}.$$

These formulæ include the cases that occur in practice. W. W. H. G.

963. *Electric Travelling Crane.* (Mech. Eng. 7. pp. 112–115, Jan. 26, 1901.)—Description with diagrams of a 75-ton, 4-motor, travelling crane constructed by Adamson & Co., of Hyde; longitudinal travel, 80 feet per min., cross travel, 50 feet per min., main hoist, 3 feet per min., auxiliary hoist, 10 feet per min. The efficiency of the hoist is 53 per cent. at 50 tons, and 51 per cent. at the full load of 75 tons. H. R. C.

REFERENCES.

964. *Accumulators at the Paris Exhibition.* **J. Reyval.** (Écl. Électr. 24. pp. 161–173, Aug. 4; 25. pp. 110–112, Oct. 20; 141–143, Oct. 27; 220–225, Nov. 10; 374–380, Dec. 8; **L. Jumau,** pp. 485–488, Dec. 29, 1900.)

965. *Winding of Rheostats.* **P. Girault.** (Ind. Élect. 9. pp. 525–526, Dec. 10, 1900.)—The author considers a circuit consisting of a fixed resistance and an adjustable resistance, acted on by a constant e.m.f., and calculates how the cross-section of the adjustable resistance must vary to maintain the maximum current density constant. He treats the case of a band of resistance material, uniform in thickness but of varying breadth, and finds expressions for the variation of breadth with length, with resistance, and with current. These formulæ are given also when the cooling surface is taken into account. G. H. B.

966. *Lightning Conductors.* **A. della Riccia.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 437–515, Dec., 1900.)—An elaborate paper in which the subject of lightning conductors is discussed from the point of view that lightning is comparable to the oscillatory discharge of a condenser, and in which recent theory of such alternating currents is applied in deciding the forms to be adopted. E. H. B.

967. *Water Turbines.* **A. Luraschi.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 403–436, Dec., 1900.)—A description of various arrangements for regulating the speed of turbines côupled to dynamos either by brakes or governors. H. R. C.

968. *Traction Cells.* **J. Zacharias.** (Centralblatt f. Accumulatoren- u. Elementenk. 1. pp. 5–8, 1900.)—A short description of the chief types of accumulators that have been used for electric traction is first given. Then follows a more complete description of the "Monobloc" system of manufacture. W. W. H. G.

969. *Three-Phase Travelling Crane.* (Elect. World and Engineer, 37. pp. 310–311, Feb. 23, 1901.)—A short article describing a crane made by Ganz for the Hungarian State Railway. Drawings are given showing some of the details.

GENERATORS, MOTORS, AND TRANSFORMERS.

970. *Magnetic Flux in Dynamo Air-gaps.* **W. E. Goldsborough.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 25–69, Jan., 1901.)—The author has previously outlined a method for determining the flux in dynamo air-gaps [Abstract No. 909 (1899)]. He now elaborates this method and applies it to find the distribution of the magnetic flux in the air-gaps of a modern two-phase machine. This had previously been found experimentally, and there is a close agreement between the calculated and the observed flux. He begins by taking the case of a single rectangular pole and a flat armature, and assumes that the number of lines of force that connect a point on the armature with a point on the surface of the pole is directly proportional to the magnetic potential difference between the points and inversely proportional to the distance between them, this latter distance being the minimum distance *in air*. The two-dimensional problem is the one considered. The strength of the field at any point on the surface of the armature is then found by integration over the surface of the pole. [A more rigorous mathematical solution has been given by F. W. Carter, see Abstract No. 2101 (1900).] By superposing the magnetic fields due to two opposite poles placed near together, he shows how to get the curve of the surface density of the magnetic flux on the armature, and also gives the curve of the surface density on the poles. He then determines the leakage field between the poles, and by superposing his two results he gets the actual flux distribution over the polar surfaces. The effect of slots in the armature is considered. Mathematical formulæ are then worked out for various simple cases. The concluding half of his paper gives a practical application to a two-phase alternator. N. Kohn and L. S. Arnot had made a complete experimental investigation on the magnetic flux in the air-gap of this dynamo in their thesis for an engineering degree. The author's calculated curves agree closely with the observed curves. The width of the teeth of the armature is 4·1 cm., and the width and depth of the slot are 1·9 cm. and 4·9 cm. respectively. He finds that 82·2 per cent. of the flux that enters the armature enters by the tops of the teeth. The surface density of the flux at the sides of the slots diminishes very rapidly until a point about half-way down the tooth is reached, after which it falls off more slowly. When the bottom of the slot is reached the flux density has diminished until it is only 4·2 per cent. of the density at the top of the tooth. Half-way down the tooth the density is 7·9 per cent. As the flux density changes so rapidly at the corners of the teeth it was exceedingly difficult to get its value accurately by experiment. A. R.

971. *Design of Alternators.* **V. A. Fynn.** (Elect. Rev. 48. pp. 55–56, Jan. 11, 1901.) This is a critical letter on a series of articles by A. Heyland on the designs of large alternators (Elect. Rev., Dec. 7, 14, and 21, 1900.) The difficulty encountered in designing alternators is the production of a machine which for a fixed excitation will give a minimum drop of volts between the terminals as the load on the machine increases. Heyland gives the following advice :—(1) Saturate the poles as highly as possible. (2) Introduce as much resistance as you like at the joints in the field. (3) Reduce the variation of

magnetic leakage from no load to full load. (4) Use closed slots with small iron bridges.

The author assigns the drop of pressure to four principal causes: (1) Demagnetising eddy currents set up by leakage fields either due to armature or field current, or both. (2) Ohmic resistance of armature. (3) Increase in field leakage between no load and full load. (4) Armature self-induction. To minimise armature self-induction the author advises high induction density in the armature slots and in the pole shoes. It is not necessary to have the reluctance of the magnetic circuit high. Such a course produces too costly a machine. W. G. R.

972. *Induction Motors.* **B. A. Behrend.** (Elect. World and Engineer, 36. pp. 676–678; 725–726; 767–769; 802–805; 843–845; 884–886; 920–922; 998–1001, 1900.) A valuable series of articles describing the practical theory of the alternating current transformer, taking magnetic leakage into account, and its application to the theory of the induction motor. Some of the novel theoretical points mentioned have been previously discussed by the author in the Elektrotechnische Zeitschrift. The chapters containing experiments on magnetic leakage are entirely new. Neglecting at first the ohmic resistance of the primary, the author defines the leakage factor (σ) by the equation $\sigma = \frac{1}{v_1 v_2} - 1$, where v_1 is the ratio of the magnetising force of the primary that extends into the secondary to the total magnetising force of the primary, and v_2 is the corresponding ratio for the secondary circuit. He then gives and proves the well-known construction for the primary and secondary currents in a leaky transformer. He next tests this construction by experiments on a three-phase motor with its armature at rest, and shows that the extremity of the primary current vector lies approximately on a circle. He proves that the maximum possible power-factor of the primary of a leaky transformer is $\frac{1}{2\sigma + 1}$.

The formulæ for the three-phase motor are next given, and he proves that the starting current of a polyphase motor can never be smaller than the running current unless the motor be started under conditions, such as higher or lower voltage, different from those under load. The relative advantages of open and closed slots are discussed by showing short-circuit characteristics of an armature with the slots opened and closed respectively. He concludes that, if the iron bridges be thin in closed slot motors, then they are in no way inferior to open slot motors. The latter, however, are cheaper to wind.

To find the influence of the air-gap (Δ) upon the leakage factor (σ), a three-phase motor was made with two armatures, one with an air-gap 0·5 mm. and the other with an air-gap 1·5 mm. The following figures were obtained:—

	1st Armature.	2nd Armature.
Δ	0·5 mm.	1·5 mm.
Magnetising current......	3 amperes	7 amperes
Short-circuit current......	42 amperes	47·5 amperes
Volts	110 in each phase	110 in each phase
Watts consumed	8,550	9,100

From these data he calculates that in the first case σ is 0·058, and in the second 0·128. This experiment seems to show that the leakage factor is proportional to the magnetising current, and also that the overload that a motor is able to stand is independent of the air-gap. The air-gap influences merely the strength of the magnetising current, but not the output.

He proves theoretically, and verifies by a series of tests, that σ varies inversely as the pole-pitch (p); hence we may write,—

$$\sigma = c\frac{\Delta}{p},$$

where c is a factor depending on the shape and size of slots, &c. It is shown how to wind a motor for different speeds, and the numerous drawbacks of a high frequency are pointed out. The following table illustrates these drawbacks :—

Frequency.	Leakage Factor.	Maximum Power Factor.
25	0·05	0·91
50	0·10	0·83
100	0·20	0·715

The design of a three-phase current motor for 200 h.p. is completely worked out, and also the theoretical data for a single-phase motor. The author emphasises the fact that the loss in the armature of a single-phase motor for the same slip is double that in the armature of a polyphase motor. Tests of a 10-h.p. motor are given which experimentally verify his results.

The author examines the results obtained by running a 200-h.p. three-phase motor as a single-phase motor and finds that in the latter case the output would be 35 per cent. less. In conclusion, various neat polar diagrams are given for the general alternating current transformer. A. R.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

973. *Calculation of Three-Phase Distribution.* **D. Stojsavljević.** (Zeitschr. Elektrotechn., Wien, 19. pp. 32–35, Jan. 20, and pp. 48–51, Jan. 27, 1901.)—The necessary calculations required in dealing with polyphase high-voltage long-distance transmissions are explained by means of an example. It is supposed there is a total demand of 2,850 kw. at five places. The total load to be 75 per cent. for power and 25 per cent. for lighting. The primary voltage is assumed as 10,500 and the power-factor for the motor load 0·7. A line of 27 km. length with 10 per cent. lost watts gives the size of wire at 165 sq. mm. With 100 ∿ and the wires on the posts 100 mm. apart, the self-induction is calculated to be 0·0262 henry. With assumed constants the voltage losses are calculated in the line and transformers. The details of the calculations are given very completely. W. W. H. G.

974. *Electric Power Distribution in Factories.* **W. B. Esson.** (Electrician, 46. pp. 461–464, Jan. 18; and pp. 503–506, Jan. 25, 1901. Paper read before the Civil and Mechanical Engineers' Society.)—This paper deals with the consideration of the conditions under which, in workshops and factories, electrical distribution is preferable to that by shafting. As the result of tests on 100 small engines, working under varying conditions, Bryan Donkin found that the average consumption of steam was 150 lbs. per i.h.p.-hour. Moreover, in cases where machinery is driven by shafting, it has been found that about 45 per cent. of the i.h.p. is available at the machines to drive the tools. In eight factories in America, the average power available was 56 per cent., while at the Baldwin Locomotive Works, it was only 20 per cent. of the i.h.p. of the engines. From tests made in 300 factories in France, the figure has been put at 60 per cent. Taking, then, the most favourable case from the point of view of the shafting-driven plant, it may be said that at full load we get 60 per cent., at half load 43 per cent. of the i.h.p. available at the machine end, and so on. Comparing electrical distribution with these results, and supposing the distribution to be effected without the use of any shafting, the author finds that a saving of 10 per cent. of the i.h.p. may be effected at full load, and at three-quarters, half and quarter loads, the saving is respectively 16, 24, and 38 per cent. of the respective i.h.p. The saving in steam is rather less than this, being possibly, for instance, at three-quarter load about 13 per cent. The money value of the saving realised depends on the cost of fuel. Independently of this, much depends on the disposition of the plant to be driven, and the time during which it is under full load. It must, moreover, be borne in mind that the capital expenditure in the case of electrical distribution is greater than in that of the shafting-driven plant. Various cases are, therefore, considered more in detail, and it is stated that the capital expenditure for generator, switchboard, conductors, motors, and fixing will amount on an average to about £20 per h.p. of the motors installed. An engine is necessary in any case, and may be taken at £3 10s. per i.h.p. The cost of shafting and belting is a very variable quantity, but may be put roughly speaking at about £5 per h.p. Interest and depreciation are put down at £2 per h.p. for electrical distribution, and £1 per h.p. for mechanical distribution. To make the adoption of electrical distribution desirable, it must be possible in any case to show that at least £1 will be saved per h.p. per annum. Each case must, therefore, be considered on its merits. W. H. S.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

975. *Southampton Tramway and Lighting Station.* **H. G. Nicholson.** (Electrician, 46. pp. 421–425, Jan. 11, and 496–501, Jan. 25, 1901.)—This power station, which supplies current both for lighting and traction, contains both alternating and direct-current plant. The alternate current is supplied to the outlying suburbs for lighting purposes, and the plant consists of three 120 kw. alternators. The direct-current machines are mostly of small size from 100 kw. downwards; a 300 kw. machine is, however, to be shortly added. The traction switchboard is fed through feeders which pass first through the main low tension switchboard, the two being otherwise quite independent, and in different parts of the station buildings. The smaller machines, originally used for lighting purposes only, generate current at 250 volts, and are therefore joined on the main switchboard so that pairs of them are in series, and thus supply current at 500 volts to the traction switchboard. This pressure is further increased by boosters, which are compound wound, in such wise that the pressure between the feeder bus-bars is about 515 volts at no load, and 550 volts at full load. There is also a tramway battery, and another smaller one for lighting. The tramway battery consists of 236 Tudor cells of 1,900 ampere-hours capacity, when discharging for five hours; it is charged by means of a motor-booster, which adds 140 volts, and makes up to 600 volts, which pressure is required when the cells are nearly fully charged. There are five tramway feeders, ranging in size from 0·3 square inch down to 0·079 square inch. A plan of Southampton is given, showing the points to which the various feeders are run. The trolley wire is No. 00 gauge. Side poles with brackets are mostly used; in some places where the brackets would have to be longer than 20 feet, centre poles are used. The swivelling trolley head is used, the distance from the trolley wire to the centre of the track being in some places as much as 7 ft. 2 in. Under the Bargate a single trolley wire is run, the height of this from the ground being 14·4 feet. An automatic switch is used in connection with this, so that the wire is always dead except when a car is passing through. This is necessary to prevent persons on the top of omnibuses, &c., from getting shocks accidentally. The connections to this switch are shown by a diagram, and the method by which the passage of the car switches the current on and off is described. For the most part the track is double, though about one-eighth is single track, and short lengths consist of interlaced lines. The steepest gradient is 1 in 17, and the sharpest curve has a radius of 40 feet. The rails weigh 86 lbs. to the yard, and were supplied in 45-feet lengths. The groove in the rail is 1⅛ inches wide, and 1 inch deep. The resistance to traction on these rails taken up an incline of 1 in 88 was 27·2 lbs. per ton, the car reaching a speed of 19·4 miles per hour, and in going round a curve of 50-feet radius, the pull was 110 lbs. per ton. At all the junctions, and on the part of the track leading into the sheds, cut crossings are used, as they give a smoother track than cast steel crossings where variable angles are required.

The article contains full diagrams of the main low tension switchboard, and of the traction switchboard; also a plan of the station buildings, and several photographs. W. H. S.

976. *Beckenham Electricity Works.* (Elect. Rev. 48. pp. 22–25, Jan. 4, 1901.)—This station is worked in conjunction with a dust destructor. The Horsfall destructor is employed, and the products of combustion pass from the furnaces through the boilers, and thence through a dust-catcher to the chimney. Alternating current is supplied to the consumer from substations on the three-wire system. The station is designed on the usual lines, except in so far as the dust destructor is concerned; but no drawings are given showing the arrangements of the flues. W. H. S.

977. *Electrical Equipment of the Manhattan Elevated Railway, N.Y.* (Street Rly. Journ. 17. pp. 1–47, Jan., 1901, and Elect. World and Engineer, 37. pp. 10–14, Jan. 5, and 89–93, Jan. 12, 1901.)—The Manhattan Elevated Railway comprises 75 miles of line with some 200 trains, and carries nearly 200 million passengers a year. The heaviest steam locomotives in use weigh 34,000 lbs. on the drivers, and can pull a train of five loaded cars at 14 to 17 miles per hour. During last year the locomotives consumed 226,924 tons of coal and 535 million gallons of water. In less than two years the gigantic undertaking of electrically equipping the whole system has been suggested, planned, and practically completed. The engines are expected to be in operation by June 1st next.

Buildings.—The main power station (the largest in the world) on the East River is designed for 100,000 h.p., with provision for 50 per cent. future extensions. It is 400 feet long by 204 feet wide, divided longitudinally and almost equally into engine-house and boiler-house, the latter containing a basement, two boiler floors and coal pockets immediately under the roof, the height being 128 feet. A freight elevator is provided to lift horse and coal-cart to top floor in case of accident to the coal-conveying plant. The engine-room is spanned by a 50-ton electric crane. The building contains 6,000 tons of structural steel-work. Excavation of the site began August 27, 1899, and the building was ready for the roof in January, 1901. There are four chimney stacks, each 17 feet inside diameter by 278 feet high, the largest in the country. They were begun July 11, 1900, and finished December 15th. The engine foundations are 40 feet square by 21 feet high. There are seven similar substations each about 100 feet long by 50 feet deep, with four stories, the two upper ones for storage batteries, the first floor for switchboards and static transformers, and the ground floor for rotary converters. A 25-ton crane is provided for the rotaries.

Nine alternative systems were considered by the Engineering Board, and the one adopted comprises three-phase alternators delivering power at 11,000 volts into three-conductor cables, which convey it to step-down transformers in seven substations, where rotary converters receive the three-phase current at 390 volts and give out direct-current at 625 volts for the third-rail. The 11,000-volt cables, weighing 9 lbs. per linear foot and having a diameter of nearly 3 inches, are drawn into vitrified clay ducts laid in cement and surrounded by concrete.

Engines and Boilers.—The main power-house contains eight complete and practically independent units, each consisting of one steam alternator, four batteries of boilers, and auxiliaries. Each chimney stack serves two such units. Coal-conveying plant can unload coal from barges into the bunkers on top floor at the rate of 150 tons per hour. The bunkers, which are three in number, separated by 35 feet of air space, hold a 20-days' supply, viz., 15,000 tons. From the furnaces the ashes pass down chutes to the basement into dump cars hauled by an electric locomotive and tipped on to an ash-pit, whence a bucket conveyer carries them to storage bins on the river front. There are 64 Babcock boilers of 500 h.p. each, constructed for working at 200 lbs. per square inch, with Roney mechanical stokers capable of burning hard or soft coal, either separately or mixed. These stokers require 90 men only, whereas hand stoking would require 270 men. For every two batteries of boilers there is one Green's Economiser. The four chimney stacks are designed to give the requisite draught naturally; but sixteen Sturtevant blowers, each capable of delivering under the boilers 57,000 cubic feet of air per minute at a pressure of one ounce per square inch, are provided to cope with sudden loads. They are driven by direct-coupled alternating-current motors. Eight triplex single-acting boiler feed pumps are driven by 500-volt direct-current motors. There are eight Allis compound horizontal and vertical cross-compound engines, essentially comprising two compound-engines working at either end of the shaft, the h.p. cylinder being horizontal and 44 inches in diameter, and the low pressure vertical and 88 inches in diameter, stroke 60 inches; the two cranks are set at 135°, and the speed is 75 r.p.m. The condensers are Worthington's, arranged at present for jet condensing, but capable of easy alteration to surface condensing when a satisfactory system of extracting cylinder oil has been found. Condensing water is drawn from the river through a rock tunnel 8 ft. 6 in. wide by 12 ft. 3 in. high. Feed water is taken from a 12-inch connection to the city mains. In an emergency a centrifugal pump can deliver salt water from the river into the boilers, and this is not expected to do much harm. The feed and steam piping is on the ring system. At each engine is a steam reservoir 3 feet in diameter by 2 feet long. Four 300-h.p. Harrisburg exciter engines run at 200 r.p.m., with cylinders 15 inches and 25 inches by 18 inches stroke. All auxiliaries are electrically driven, those required to operate before the main engine can be started being wound for 500 volts direct current, supplied by a special battery. The total number of lights on the Company's buildings is 15,000 incandescent, and 250 arcs, and these are supplied from the substations through a motor-generator for raising the frequency from 25 to 60 cycles per second.

Alternators.—The alternators are the largest in the world, and are of the revolving field fly-wheel type. The fields are keyed to the engine shafts, and weigh 370,000 lbs.; the whole alternator weighs 889,000 lbs., and is 42 feet in height. The normal output of each alternator is 5,000 kw. at 75 r.p.m., *i.e.*, 263 amperes per terminal at 11,000 volts under non-inductive load, with a frequency of 25 cycles per second; each alternator field then requires 225 amperes at 200 volts. If the power factor of the circuit is 90 per cent., the field current will be 15 per cent. more than this. If 263 amperes per terminal at 11,000 volts at 100 per cent. power factor are suddenly thrown off, the rise in voltage is guaranteed not to exceed 6 per cent. with constant speed and field. Under non-inductive load the efficiencies are to be 97 per cent. at 25 per cent. overload, 96·5 per cent, at full load, 95·5 per cent. at $\frac{3}{4}$ load, 94·5 per cent. at $\frac{1}{2}$ load, and 90 per cent. at $\frac{1}{4}$ load. These efficiencies cover the C^2R losses in armature and field coils and the armature iron losses, but not mechanical friction. The machines will give their normal output under non-inductive load for twenty-four hours without exceeding a rise of 35° C. With 50 per cent. overload for two hours the rise is not to exceed 55° C. The field winding consists of one layer of copper strip on edge, with the insulating material cemented in place between turns. To prevent hunting, copper wedges are used with large lips which overhang the bevelled edges of the field poles. The armature consists of bars in slots on the inner face of a laminated ring, and its insulation is subjected to a puncture test of 25,000 volts alternating for thirty minutes, or 35,000 volts for one second. The field pole tips are bevelled at the edges to produce a field of such form that with a star type of three-phase winding, the e.m.f. wave will be practically a sine wave at no load. The field produced by cross magnetisation with load and magnetic leakage around the conductors will be of such form that the e.m.f. produced thereby in the armature windings will also be practically sine-shaped. As the resultant of this wave and the no-load wave form gives the wave form with load, the full-load wave-form will necessarily be very nearly sine-shaped. There will be four armature slots per phase per pole, thus securing a distribution of the coil which should produce a wave practically free from irregularities, and a wave which is the same within close limits for different loads. By this means the harmonics, which are liable to occur with a winding in which there are but few slots per phase, are avoided together with their possible evil effects in connection with the capacity and self-induction of the very extensive system of cables and transmitting apparatus to which the alternators are to be connected. Another advantage attained by the use of a large number of partially closed slots in the armature core is the possibility of using copper dampers over the pole-tips. If the armature had wide teeth and large open slots, the use of such dampers would obviously cause considerable, if not inadmissible, losses due to eddy currents.

Switch-Gear.—Each of the three-conductor cables from the power-house to the substations is equipped at the power-house end with an oil circuit-breaking switch with a time-limit relay device, so that in case of a short-circuit in the cable the supply of power from the power-house shall be interrupted at the end of a predetermined interval, say three seconds. At the substation end the cable is connected to the bus-bars through a similar oil circuit-breaking switch, but in this instance the automatic device is arranged to open the switch instantly in case of a reversal of the current such as would be caused by a short circuit in the cable. Similar cut-off arrangements are made in the substations. The generator panels of the exciter board control only one pole, the positive main switches being placed with the exciter switches and equaliser switches on pedestals near the machines. The exciter bus-bars are in duplicate, with throw-over switches to each circuit. There will be an emergency arrangement on the main operating gallery for discharging simultaneously the fields of all generators operating in parallel. All cables in the power-house will have fireproof covering of asbestos. The 11,000-volt oil break switches are of the "G. E. Type H," each phase being isolated in a special enclosed brick compartment containing two enclosed brass vessels partially filled with oil below the surface of which the circuit is broken. The switching apparatus is controlled electrically without the intervention of compressed air. The switches are operated by powerful springs which are released and then wound up by electric motors. Signal lamps indicate the integrity of the motor circuits. The motors, and therefore the switches, are in turn controlled by electric circuits, which pass through small switches immediately under the hand of the operator, upon a bench board, the controlling switches being so arranged in conjunction with certain dummy bus-bars and connections as to place at all times before the eye of the operator an accurate diagrammatic representation of the existing connections of alternators, switches, bus-bars, and feeders. The switching apparatus is on two galleries 400 feet long. The pilot diagrams are so drawn that the switch handles apparently open and close the diagrammatic circuit. A motor governor controller is provided for equalising the division of the load between alternators. A 110-volt storage battery is provided for operating the switchboard motors. Immediately behind the bench boards are instrument panels containing for each machine three ammeters, a voltmeter, a 10,000 kw. watt-meter, and a power-factor indicator. This last instrument will also serve as an automatic signalling device between substations and the power-house. If the voltage delivered by the alternators at the power-house is too low, the substation attendants will attempt to raise it by cutting out the field resistance of the rotary converters, thereby drawing leading currents from the power-house. This will be shown on the power-factor indicators of the alternators, whereupon the operator at the power-house will raise his voltage to meet the requirements of the substations, restoring the power factor to unity. The reverse sequence of operations will occur when the direct-current voltage is too high.

Substations.—The switching apparatus in substations is on the same lines as in the power-house. It has not been finally determined whether the converters will be regularly synchronised on the high-potential side of the step-down transformers by means of the oil-switches or on the low-potential side of the transformers by means of the hand-operated switches. Each rotary converter is supplied by a group of three 550-kw. step-down transformers which have loops brought out from the primary windings for adjustment purposes. The transformers are of the air-cooled type, motor-driven blowers being provided; their guaranteed efficiencies are 97·7 per cent. at 25 per cent. overload, 97 per cent. at ½ load and 95 per cent. at ¼ load. For a 25 per cent. overload run of twenty-four hours, the temperature rise will not exceed 45° C. The rotaries are each capable of delivering 1,500 kw. continuously, and 2,250 kw. for some hours. They run at 250 r.p.m. with efficiencies of 96 per cent. at 25 per cent. overload, 95·25 per cent. at ¾ load, 93·5 per cent. at ½, and 89·0 per cent. at ¼ load. The field frame is of cast iron, while the pole-pieces are of laminated steel. The pole faces are bevelled at the edges to permit the use of copper shields, which consist of heavy copper rings around the pole-tips, having lips extending from both edges of the pole toward the centre to prevent hunting. The converters are guaranteed to stand an overload of 100 per cent. without hunting or falling out of step. Their fly-wheel effect is made as small as possible because it tends to force them to act independently of changes in the system. The copper shields on its poles tend to force the converter to promptly follow any changes in the system. A motor generator set is provided for starting up the converters by direct current. The reason for the large size of converter is the value of ground space. The largest substation is 50 by 100 feet by 70 feet high, but they each contain 9,000 kw. of converting apparatus as well as a 3,000 kw.-hour storage battery with the necessary boosters.

Third Rail.—The third rail is of a standard section weighing 100 lbs. per yard and rolled in 60-feet lengths. Investigation having shown that reduction of percentage of carbon and manganese tends to increase the conductivity, the composition was specified to be carbon 0·073 per cent., manganese 0·341 per cent., sulphur 0·073 per cent., phosphorus 0·069 per cent. This gives a rail too soft for ordinary track service, but it has only about eight times the resistance of copper. The third rail has a sectional area of 9·8 square inches, and, where the length between substations does not exceed 6,500 feet, with 6-car trains running on a 15-m.p.h. schedule with one minute headway, the voltage drop will be about 10 per cent. The third rail is insulated with wooden blocks from the sleepers, and is divided into 300-feet lengths, with anchored expansion joints, the lengths being bonded with "protected" bonds in the bottom flange. Wooden guard strips, 2 inches higher than the third rail, are fixed on either side of it. The 90-lb. track rails and the longitudinal girders of the structure are bonded with 0000 stranded cable, welded to copper terminals which are hydraulically compressed into reamed holes. [See also Abstract No. 584 (1901).] The power required at the third rail will vary between 60,000 h.p. during "rush" hours, and 5,000 h.p. for the "owl" cars, the average being 30,000 h.p. This involves an unusual amount of switching. E. H. C.-H.

978. *Three-wire Tramway at Grenoble.* **E. Legrand.** (Écl. Électr. 26. pp. 124–129, Jan. 26, 1901.)—Forty-three kilometres of line between Grenoble and Chapareillan are worked on a three-wire system, the middle wire being the rails and the outers being two trolley wires carried side by side. The two motors on the cars are thus run in series across the outers at 1,200 volts.

The generating station at Lancey, 12 km. from Grenoble, contains three turbines, each giving 340 h.p. at 325 r.p.m., the water being supplied at a pressure of 45 atmospheres from a fall 450 m. high through a riveted zinc pipe. The tail-race water is measured for purposes of payment by being passed into a cylindrical tank with eighty windows, exactly equal, having their sills in one horizontal line, the outflow from one window being easily measured in a graduated vessel. Each turbine drives, through a Raffard coupling, a six-pole compound-wound dynamo giving 417 amps. at 600 volts, provided with Thury automatic shunt regulator to give constant voltage. As the drops on feeders would ordinarily be very great (150 to 250 volts), boosters are used on each feeder. Each pair of feeders has two series-wound boosters driven by one compound motor. In this way the voltage drop is kept within 60 volts. Each booster has a device at the end of its shaft for automatically short-circuiting the armature if the direction of rotation is reversed; this is to guard against the booster racing backwards as a series motor if the compound-wound motor fails. Each car carries two rubbing contacts of antifriction metal. E. H. C.-H.

979. *Electrical Distribution in Colorado.* **J. R. Cravath.** (Elect. World and Engineer, 37. pp. 115–118, Jan. 19, 1901.)—Notes of some interest on the system of distribution used in the greatest gold-mining camp of America, known as the Cripple Creek District, are given. The district includes two large towns, six smaller towns, a number of large mines, and hundreds of claims in various stages of development. Coal is worth at least $6 a ton at the mines, and water is also scarce. The region, therefore, appears well adapted for electrical power transmission. Two electrical companies are working, and a third is about to be formed. The power rates are from 2 to 4 cents per B.T.U. Air compressers, pumps, and hoists furnish the chief load. For hoisting, the type of induction motor always used is regulated by a tram type of controller which introduces resistance into the rotor. This method is found much more satisfactory than the use of auto-converters or reactance-coils in the stator. Of the three plants, one generates power 24 miles away by steam, one has steam plant in the district but is closely identified with the railway which brings the coal, the third uses water power 11 miles away. The first of these is *The Colorado Electric Power Company*, which has its power-house at Cañon City, where coal and water are cheap. The system is three-phase, 20,000 volts, 30 ∾. There are two substations which distribute power locally at 500 volts, three-phase. From one of the substations a 2,500-volt line runs to a distant mine, and a 6,600-volt line from the other substation to supply an electric railway power-house. The area of distribution is about 6 square miles, in which the 500-volt distribution forms a network tied together at many points. In substation No. 1 there are four 200-kw. transformers, one being in reserve, for 20,000–500 volts; there are also four 100-kw. transformers for 500–2,500 volts to supply the distant mines. At No. 2 there are also four 200-kw. transformers for 20,000–500 volts, and four 200-kw. for 20,000–6,600 volts for the electric railway power station, where there are transformers and rotary converters. The transformers are all oil-insulated Westinghouse, excepting four Stanley's and one 100-kw. General Electric make.

The transmission from Cañon City is over a mountainous country, and might have been expected to have been much affected by lightning. This has not been the case. Every five miles a bank of Wurts cylindrical non-arcing metal lightning-arresters are placed 16 in series on each line. They are enclosed in porcelain and fixed inside a box on a pole. Choking coils and a similar bank of arresters are provided at each end of the line. The line is of No. 3 copper wire on Mershon insulators, 6 inches diameter and triple petticoated. These have done good service. The wires are 50 inches apart, two on a cross-arm and one on a pin at the top of the pole. Current is kept on the system 24 hours a day and every day in the year. All repairs and alterations are made with current on the line. The plan adopted in changing the insulators and handling the 20,000-volt line wire is to connect the line which is to be handled with a nail in the pole at a point below where the linesman stands when working. This "jumper" makes a better earth than the linesman's body, and hence he is unharmed.

The loss in the line and transformers is 18 per cent. At the substations are fuses of thin copper wire 23 inches long enclosed in thin rubber tube. These have proved successful circuit-breakers. Facilities are provided for cutting out a transformer and substituting the one in reserve. In case the fuses on one of the transformers blow, the other two legs of the circuit will usually carry the load for a short time until the reserve one can be switched on.

On the 500-volt line, lightning is a much more dreaded enemy. As a means of protection the original plan was to put up a cross-bar on the pole and fix three pins on it for the three-phase wires; then barbed wire was secured by staples directly at each end of the cross-arm and to the pole-top. This resulted in short circuits owing to the copper stretching more than the iron wire, but these were avoided by fixing short brackets on the end of the cross-bars, so as to keep the barbed wires further from the copper.

At the power-house at Cañon City the plant consists of three units, each of 30 ∿, three-phase Westinghouse generators direct-connected to Hoover-Owens and Rentschler-Corliss compound condensing engines. The exciters are independently engine-driven. The transformers are four 500 kw. In the secondary circuit the 20,000-volt current is opened by switches with a 4-feet break. Automatic circuit-breakers are used at the time the machines are thrown in parallel, but on account of the sudden fluctuations of the load the circuit-breakers are fastened up after the machines are in circuit and the fuses depended upon. H. H. Wilson, chief engineer, has devised a good method for synchronising.

The La Bella Mill, Water and Power Company.—The generating plant consists of McIntosh and Seymour compound condensing engines direct-coupled to 600-kw. three-phase, 6,600-volt General Electric revolving field generators. There are three units. The high-voltage circuits are taken to substations in eight towns and transformed to 110 volts on a three-wire system. In one station direct-current arc machines are driven by induction motors.

The Pike's Peak Power Company.—Water-power under a 1,000-feet head will drive four Pelton wheels directly connected to General Electric 400-kw three-phase generators. The transmission will be at 12,000 volts.

W. W. H. G.

980. *Snoqualmie Falls Power Transmission.* (Eng. News, 44. pp. 398–404, 1900.)—The Snoqualmie Falls are in Washington, thirty-five miles from Everett; the river has a flow varying from 1,000 to 10,000 cubic feet per second, and the height of fall is 270 feet. A concrete dam 210 feet long is built across the river, just above the falls; it is always submerged, and raises the level 6 feet at low water. A rudder boom 300 feet long is moored above the intake and extends beyond it; by turning a capstan at the head of the boom the rudders are thrown out and cause the boom to swing out into midstream, so that it serves as a fender to deflect floating logs, &c., from the intake. The intake-bay is double, only one bay being used at present; it is constructed of concrete, and is protected by a horizontal timber grating with 12 inch spaces, and behind this is a grating of flat steel bars on edge. About 300 feet above the falls is a shaft 10 feet × 27 feet, descending 270 feet to the bed of the river below the falls. At the bottom is the power-chamber, 200 feet long, 40 feet wide, and 30 feet high; from this a tunnel 650 feet long forms the tail-race. The penstock is a steel pipe 7½ feet in diameter, which passes through the concrete floor of the intake; the plates are in eight courses, and vary in thickness from ½ inch to 1 inch. At the bottom of the shaft the penstock connects to a horizontal cylindrical receiver 10 feet in diameter, extending the length of the power-chamber. At four points are 4-feet branches, each with a gate valve, which connect with the horizontal receiver of a water-motor.

The Doble water-motors of 2,500 h.p. each are four in number, each consisting of six tangential jet wheels with two nozzles to each wheel. The nozzle orifice is regulated by the axial motion of a "needle" having parabolic curves running to a point; this, as the needle is moved in or out, gives an annular opening of greater or less width, while always maintaining a smooth jet of water. The needles are regulated by a Lombard governor. The wheel buckets have an ellipsoidal form, with centre rib to split the jet, and the lip of each is notched in the centre to allow the jet to impinge on the rib in the position of greatest efficiency as soon as it strikes the bucket. The wheels are 45 inches in diameter with thirteen buckets, the latter being separately replaceable when worn. The wheels are encased in sheet-steel housings, centrifugal discs on the shafts preventing the escape of water where the shafts pass through the housing; these centrifugal discs are found to be more efficient than the packing-boxes and glands which were first fitted. Separate 75 kw. wheels drive the exciters.

The electrical plant comprises four 1,500-kw. Westinghouse generators of the revolving armature type. They give each a three-phase current of 1,000 amperes per phase at 1,000 volts and 60 periods, running directly coupled to the water-wheel shafts at 300 r.p.m. In the transformer chamber at the head of the shaft the voltage of 1,000 is transformed to 30,000, which is the nominal voltage of transmission. The entire station is operated by two men only. The transmission lines are two—one 32 miles in length to Seattle, of 264 mils. aluminium wire; the other 44 miles in length to Tacoma, of

234 mils. aluminium wire. All the lines were joined in series for an experimental test in transmission, giving a total length of line of 158 miles, starting from and returning to the station; a 1,500-kw. machine was connected at each end, one working as a synchronous motor. The apparent kilowatts required to charge the line were at 22,500 volts 62 kw., at 30,000 volts 112 kw., and at 35,000 volts 180 kw. When the voltages at the beginning of the line were 22,500 and 30,000, those at the end were 24,600 and 32,100 respectively. At a constant voltage of 30,000 the apparent charging power at 50 ∿ was 100 kw., at 55 ∿ 105 kw., at 65 ∿ 115 kw. The following test was made on a non-inductive load consisting of a water resistance on the end of the line; drop of volts from 30,000, 25 per cent.; loss in amperes per phase at 1,000 volts, 11·2 per cent. from 624 amperes; loss in kilowatts 34·2 per cent. from 723. With the substation transformers at Seattle and Tacoma in circuit with open secondaries 193 apparent kw. were required to charge the line, and the drop of volts was from 31,500 to 30,000.

The transformers are thirteen in number, each of 500 kw. at 90 per cent. power factor. They are of the Westinghouse self-cooling, oil-insulated type. The high-tension winding is for 15,000 or 30,000 volts, and each layer is wound in the same direction, so as to diminish the potential between adjacent wires, the wire from the end of each layer being carried across the face of the coil to the starting side. The poles carrying the transmission lines are of cedar, 36 feet high; two cross-arms carry six porcelain insulators for the two circuits which are run on each line; the triangular spacing between the wires is 30 inches. The average length of span is 110 feet on the Seattle line and 150 feet on the Tacoma line, a sag of 15 inches being allowed. Joints are made by the McIntyre sleeve, which is a flattened aluminium tube 9 inches long by $\frac{1}{16}$ inch thick, and of a size sufficient to take the two wires; when the joint is made it is given three complete twists. There are several small substations supplying towns on the line of route; the Seattle substation is equipped with four pairs of 300-kw. and two pairs of 500-kw. transformers, stepping down to 20,000 volts. There are also three step-down transformers supplying current at 350 volts to two rotary transformers, delivering continuous current at 550 volts. The rotaries are brought up to synchronism by a small induction motor. The Tacoma substation has three 500-kw. and two 200-kw. transformers. The power available at different points on the system at full load is as follows, assuming a line loss of 15 per cent.: Energy from water = 100, from water-wheel = 80, from generator = 75, from step-up transformers = 72, to step-down transformers = 61, from step-down transformers = 59, from rotary transformers = 53. The Snoqualmie Falls Power Company does not supply power to small customers, but supplies in bulk to sub-companies in Seattle and Tacoma. The article is illustrated by a full-page plate giving plan and sections of the constructional work and illustrations of the power station and substations. There are also in the text a map, drawings of the water motors, and several photographs. [See further Abstract No. 516 (1899).] G. H. B.

981. *Chicago South Side Electric Railway.* (Tram. Rly. World, 10. pp. 1–8, Jan., 1901.)—This elevated railroad was equipped electrically in 1898, on the Sprague multiple unit system [see Abstract No. 344 (1898)], and the results have been most satisfactory. This paper deals mainly with the generating station, which was completed last May. The cost of generating per unit of net output is 0·225 of a penny, made up of: coal, 0·1875; labour, 0·055; water, 0·0125; various, 0·02. Interest and depreciation are not included.

The boilers are by Babcock and Wilcox, the working pressure being 160 lbs. per square inch. The handling of coal and ashes is done by conveyors. The coal costs 5s. 5d. per ton, and 6½ lbs. of steam are produced, on an average, per lb. of coal. The engines are Allis-Corliss horizontal condensing, running at 80 r.p.m. The smaller engines of 1,200 h.p. are guaranteed not to require more than 18¾ lbs. of steam per i.h.p. per hour. The speed is guaranteed not to vary more than 2 per cent., with a change from no load to 50 per cent. above normal or *vice-versâ*. The larger engines are of 2,400 h.p., and each has a fly-wheel 22 feet in diameter, weighing 70 tons, and built up of cast-iron in eight sections. The Westinghouse 625-volt generators are driven direct. Current is supplied to the trains by a third rail. There are battery sub-stations near the ends of the line, three miles from the power station, the batteries being simply connected between feeder and track. W. H. E.

982. *Electric Power Transmission at Butte, Montana, U.S.A.* **J. R. Cravath.** (Elect. World and Engineer, 37. pp. 149–150, Jan. 26, 1901.)—Power is generated on the Big Hole River, 21 miles from Butte, by Leffel horizontal turbines driving four 750 kw., 60-cycle 800-volt three-phase alternators. The pressure is raised to 16,000 volts for the transmission line, and transformed down to 2,200 at Butte. Most of the large motors are of the induction type, but over-excited synchronous motors are also used, and a large amount of power is supplied by a 500-volt rotary converter. The synchronous motors are mostly old 125-cycle single-phase alternators rewound. The lighting circuits were formerly on a single-phase system, and the two-wire feeders are now balanced as well as possible on the three legs of the Y by a plug switchboard. The transmission line is protected against lightning by a barbed wire earthed at every fifth post and at streams; this wire is mounted throughout on glass insulators in order to prevent corrosion. This protection has proved very efficient, although many trees are struck. The turbines are controlled by Lombard governors, and these, with the help of the inertia of the fly-wheel alternators, give excellent voltage regulation, as good as with a first-class steam engine. There are no fuses on the generators or high-tension lines. The average power-factor is 87 per cent. One generator is often run as an over-excited synchronous motor in order to reduce the idle current. [See further Abstract No. 449 (1898).] W. H. E.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

983. *Regulation of Tram Motors.* **K. Sieber.** (Elektrotechn. Zeitschr. 22. pp. 35–38, Jan. 10, 1901.)—Eight different methods of motor control are discussed, and a list of advantages and disadvantages is drawn up for each case. The general conclusions that immediately follow, are: 1. For cars with single motors, series motors regulated with the use of resistances in series are the best. 2. For cars with two motors, series motors with series-parallel control should be used. 3. For cars with more than two motors, series motors should still be used. The motors should be run in parallel and the fields also in parallel. W. W. H. G.

984. *Capacity and Rating of Railway Motors.* **N. W. Storer.** (Street Rly. Journ. 17. pp. 67–70, Jan., 1901.)—The author gives curves for a particular motor showing speed, horse-power, and tractive effort, for different currents, iron loss for different pressures and currents, and two time curves, one showing the time a motor may carry any current above its rated continuous current, with a rise of 20° C. when already running at its average temperature, the other the time it may carry any load with a rise of 75° C. starting cold. From these curves he works out curves showing speed, volts, and current, at each second, for a run of a quarter of a mile in 58·5 seconds from start to stop or an average speed of 14·2 miles per hour. He assumes the rate of acceleration as 1½ miles per hour per second, and the rate of braking as 2 miles per hour per second, rolling friction being 20 lbs. per ton. The speed curve is drawn by first drawing the acceleration line. This acceleration requires a constant current of 68 amperes while the full pressure is on the motors, and the line is continued until it reaches the speed corresponding to this current, and the full voltage. The current is then assumed to have fallen to 50 amperes; the mean acceleration between 68 and 50 amperes is calculated and a line is drawn, from the end of the first, representing this acceleration. This process is continued until the curve reaches the braking line drawn from the point on the axis representing 58·5 seconds. A line is then drawn at an angle corresponding to a decrease of speed of 0·22 miles per hour per second due to rolling friction. This line represents the time of coasting, and it cuts the acceleration and braking line at such points that the average speed is 14·2 miles per hour. The average copper loss is proportional to the average of the squares of currents during successive intervals. The current which, when flowing continuously, will give the same heating effect, is the square root of the mean square current. This in the example taken is 33 amperes. The iron loss is calculated for each second and the average taken, which comes to 350 watts. Therefore, to reproduce the heating conditions of this service in a shop test, all that is necessary is to run the motors at 33 amperes and at such a voltage as gives, with 33 amperes, an iron loss of 350 watts. It is not necessary to go into the refinements of iron loss to the extent that is done in this analysis. The average voltage on the motor is usually below 250, so an equivalent voltage of 300 may be taken for the continuous test, or 400 for interurban service when the shops are fewer. If the continuous capacity of railway motors is stated in terms of the current at 300 and 400 volts, it covers all classes of service with the necessary precision. The author criticises Lundie's method of rating (Abstract No. 301 (1901).)

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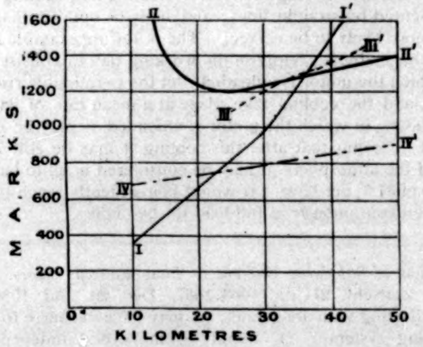
[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

R. B. R.

985. *Rating of Tramway Motors.* **M. Müller.** (Elektrotechn. Zeitschr. 22. pp. 73–75, Jan. 24, 1901.)—Tramway motors are generally rated according to the number of h.p. they transmit. Horse-power may be looked upon as the product of pull and speed. The pull to be developed depends on the weight of the car and other considerations, and the speed is largely governed by the time-table. Both factors are therefore of importance in tramway work. Theoretically it is possible by means of gearing to change a motor giving small torque at high speed into one giving a larger torque at lower speed; but practically, owing to the peculiar construction of tramway motors, and to the small amount of space available, no such change is feasible. A further difficulty arises from the fact that one and the same motor may be described as a 5, 10, 15, or 20-h.p. motor; the ratings depending on differing hypotheses as to the length of time under load, and the permissible rise of temperature. Since there are no conventions on the subject, manufacturers differ widely among themselves. The author suggests that a rating such as 100/15 might be taken to denote a motor that gives a pull of 100 kg., and a car speed of 15 km. per hour, it being understood that the voltage is 500, the wheel diameter 30 inches, and that the motor will not have more than a certain temperature rise if run for a certain time at full load. With regard to the amount of temperature rise, and the time of loading, these must be matters of convention. The American practice seems to be to rate their motors at the number of h.p. which they can give out for one hour without rising in temperature beyond a certain limit; and this limit is determined by the fact that mica insulation can stand a temperature of 100° C. without sustaining any damage. Therefore for Northern Europe, the rise in temperature may be fixed at about 75° C. It is, however, difficult to say whether the period of one hour is sufficient. The author considers the question mainly from the graphical point of view, and designedly simplifies his calculations by assuming that, within the limits considered, the curves showing the rates of heating and cooling of the motor may be represented by straight lines; and he is of opinion that a period of two hours is more likely to be correct. The following example may be taken as illustrating his method. Suppose the working day to consist of 16 hours, during 8 of which the motor is unloaded; let the permissible rise in temperature be 75° C., and the cooling take place at a mean rate of 28° C. per hour. During the 8 hours, in which the motor is unloaded, it may be considered in all to lose 224°. Seeing that after this cooling it may be still 75° above the temperature of the atmosphere, it may be considered in all to have risen 299°, *i.e.*, at the rate of 37·5° per hour. It would consequently reach the prescribed rise of 75°, if run continuously at full load for two hours. W. H. S.

986. *Methods of Supplying Current to Long Railway Lines.* **G. Rasch.** (Elektrotechn. Zeitschr. 21. pp. 1063–1067, Dec. 20, and 1080–1083, Dec. 27, 1900.)—In dealing with long lines, we may have recourse to one or other of the following systems: (1) Supply from several independent central stations; (2) Supply from one central and one or more substations, the transmission of power from the generators to the substation transformers taking place at a high pressure by means of polyphase currents, which, by the use of rotary converters, are further transformed into continuous currents; (3) Three-phase system of traction, the car-motors being supplied with three-phase current from transformers whose primaries receive power from the generating station at a high pressure. Besides the above three methods, we also have at our disposal the following: (*a*) Use of boosters in feeders supplying the more distant portions of the line; (*b*) The three-wire system; (*c*) Accumulator substations. Considering the last three methods first, the author points out that the use of boosters is only economical in cases where the load on the distant portions of the line is of short duration and occurs at comparatively long intervals. The saving due to the use of a three-wire as compared with a two-wire system does not exceed 20 per cent. under the most favourable conditions, since on account of the fact that the rails have to be used as the middle conductor it is impossible to take full advantage of their high conductance. Accumulator substations, although well adapted for supplying a lighting load, which is of short duration, are not suitable for a traction load, which is spread over a large number of hours. Having dismissed methods (*a*), (*b*), and (*c*) as not being generally applicable, the author next fully discusses and compares methods (1), (2), and (3), assuming certain conditions such as commonly occur in practice. He works out the annual cost per kilometre of power transmission and distribution for the three cases. This

cost includes depreciation and interest on conductors and transforming devices, cost of energy wasted, and in case (1) also the increase in the cost of generating a unit when two or more generating stations are substituted for a single one. The accompanying curves show the results obtained on the assumption of a load of 10 kilowatts per kilometre of track for 17 hours each day. Curve I I′ refers to case (1) with a single generating station; curve II II′ to case (1) with two generating stations; curve III III′ to case (2), and IV IV′ to case (3). It is seen that so long as the length of the line does not exceed 22 km., method (1) with a single station is best. Beyond this limit, the three-phase system is best. A more detailed examination of this system brings out the following important points: (α) the size of the overhead conductor is to be determined by considerations of mechanical strength and permissible current-density, and not by considerations of economy, the latter always giving sizes which are much too small for practical use; (β) the best size of transformers lies between 12 and 21 kw.; (γ) with a heavily loaded line, the need of an extra high primary pressure makes itself felt beyond a distance of some 35 km. But this extra high pressure can be used advantageously only when generated directly, without the use of step-up transformers. In view of the above results, the author examines the reasons which have caused three-phase traction to be regarded with disfavour: the main reason is undoubtedly due to the necessity of using two overhead conductors, and the resulting complexity in the overhead construction at crossings. A. H.



987. *Methods of Working Long Electric Railway Lines.* **K. Sieber.** (Elektrotechn. Zeitschr. 22. p. 71, Jan. 17, 1901.)—A letter criticising Rasch's paper [see preceding Abstract] on this subject. The author points out that the saving effected by the adoption of a three-wire system may amount to as much as 50 per cent., instead of the 20 per cent. given by Rasch. This is due to the fact that the use of return feeders is imperative, so that in the case of heavily loaded lines the return feeders cost practically as much as the forward ones. The author further criticises Rasch's assumption of a 10-minute service, and thinks that a much more frequent service should have been assumed. A. H.

988. *Electric Railway Traction.* **E. P. Burch.** (Street Rly. Rev. 11. pp. 39–42, Jan., 1901. Paper read before the North-west Railway Club, Jan. 16, 1901.)—After an historical survey of the progress of electric railway traction, the author considers the alterations that are necessitated by the change from steam to electricity. The torque of an electric locomotive is constant, *i.e.*, it does not depend on the inclination of connecting rods, or on varying pressures on the piston. It has, therefore, about 85 per cent. greater tractive force than the steam locomotive, assuming equal weights on the drivers. With the Baltimore and Ohio locomotives, on a dry rail without sand, a tractive coefficient of 30·8 per cent. of the weight on the drivers was found, while with steam the draw-bar pull was 20·6 per cent. Moreover, in the design of electric locomotives, all the weight can be placed on the drivers; heavy steam locomotives for luggage traffic, for instance, lose by having from 10 to 20 per cent. of their weight on the truck wheels. For passenger trains, the dead weight of engine and boiler is greater than is necessary to secure adhesion. On the Empire State Express, the engine and tender weigh 37 per cent. of the total weight of the train. The author considers that with electricity the weight of the locomotive would be so much reduced as to save 25 per cent. of the total weight of the train, and consequently 25 per cent. of the power required. It is claimed that the cost of repairs to track and rolling stock would be much reduced by electric traction. This is due partly to the decreased weight of locomotives, and partly to the absence of unbalanced parts, and the consequent vibration, which acts destructively both on the track and engine. The life of a steam locomotive is put down as being ten years. Stationary boilers and Corliss engines should not cost 10 per cent. of this amount for repairs, and at the end of ten years should not show material depreciation. Further, the cost of fuel should be very considerably diminished. In 1899 it amounted to 9·47 per cent. of the total operating expenses on the railways of the United States. The conditions of working do not allow of any great economy under this head, and the ordinary luggage train requires about 5 lbs. of coal per i.h.p.-hour. A saving of 40 per cent. of the steam might be effected if simple steam locomotives could be replaced by compound condensing ones. The loss in the locomotive is very great, and was found by Goss to amount to 23 per cent. at a speed of 55 miles an hour. Considering the various losses in detail, both on the steam and electric systems, the author considers that half the coal used on existing railways might be saved, which means a saving of 5 per cent. of the total operating expenses.

W. H. S.

989. *Electric* versus *Steam Locomotives.* **W. Langdon.** (Inst. Elect. Engin., Journ. 30. pp. 124–150; Discussion, pp. 150–231, Feb., 1901.)—The cost of locomotive power for the United Kingdom (including stationary engines for pumping, &c.) averages 9·988d. per train mile. The author estimates in detail the cost of working 50 miles of the Midland Company's line between St. Pancras and Bedford, excluding the suburban traffic. From the Block Books it appears that the mechanical h.p. required to operate the trains is 3,890 h.p.-hours per hour, or 2,905 kw.-hours per hour, fourteen trains passing any given point per hour.

The proposed scheme consists of a generating station midway, containing four 2,500 kw. three-phase 10,000 volt generators, feeding substations each serving 10 miles of railway at 600 volts. To supply the above-mentioned 2,905 kw.-hours per hour, the author estimates that 5,000 kw.-hours must be generated to work the fourteen trains, which travel 479 miles during the hour. For this a generating plant capable of 10,000 kw. is ample, and the prime cost will be—

Generating station, complete	£250,000
Substations	80,000
Cables and laying	70,000
Contact rail (200 miles for the four roads)	70,000
Total capital outlay for generation and distribution	£470,000

The average cost, over twenty-four years, of drivers and firemen was 2·650d. per train mile, and of repairs and renewals in the locomotive department, 2·641d. per train mile. The estimated costs with electric working are—

	Per kw.-hour. Pence.	Per Train Mile. Pence.
Generating charges	0·1574	1·643
Substation charges	0·0299	0·312
Outdoor attendance	0·0041	0·043
Oil, waste, and sundries	0·0109	0·114
Locomotive drivers and assistants	0·2538	2·650
Repairs and renewals of machinery, motors, &c.	0·1916	2·000
Renewal of cables and contact rail	0·0249	0·259
Total cost for power and haulage	0·6726	7·021
Interest at 3½ per cent. on primary outlay, viz., £470,000	0·0901	0·941

This shows a saving of 1·922d. per train mile over steam working. Coal is based on 3·0 lbs. per kw.-hour, or 31·315 lbs. per train mile, as against the 50·191 lbs. consumed per train mile by the average locomotive. The steam figure includes shunting, and the use of less expensive coal in stationary engines would probably make the electric figure also cover it. Expensive coal enhances the comparative value of an electrical system. With steam working, water costs 0·211d. per train mile; with electric, 0·0522d. per train mile.

Discussion (pp. 150–231).—**M. Robinson** considered that four or five direct-current stations would be better than the scheme proposed, and calculated that the capital outlay would be thereby reduced from £470,000 to £273,000, while at the same time there would be a saving of 22 per cent. in running expenses. Above 3,000 h.p. there is little or no economy in increasing the size of station with high-speed engines. With American slow-speed engines economy continues to improve with size. **G. C. Cunningham** has found that on the Central London Railway the quantity of coal consumed in the power-house is 0·5 lb. per ton mile and of power is 70 watt-hours per ton mile. **H. A. Hoy** suggested using travelling generating stations containing high-speed engines and generators charging the third rail direct, and disputed the extra economy of stationary engines, which must always be turning, whereas the locomotive is frequently at rest. **R. E. Crompton** drew attention to the small load-factor of the steam locomotive, as shown by the tables, and attributed the low economy of locomotives to this fact. **G. Forbes** questioned the figure for contact rails, which he calculated would have to be 6·6 square inches in order to get 10 per cent. drop at the midway point, and would then cost £330,000 instead of the £70,000 mentioned in the paper. **J. S. Raworth** was of opinion that the power-house would have to give over 9,000 kw. instead of the 5,000 kw. given by the author. **F. Hudleston** supported this view with actual figures of power required with steam locomotive. Coal on the Underground Railway works out at ¼ lb. per ton mile, and he doubts whether the superior coal accounts for the whole difference between this figure and the ½ lb. per ton mile on the Central London Railway. **A. A. C. Swinton** pointed out that with frequent generating stations the load-factors would be low. **A. Siemens** considered electric traction practicable only where there are upwards of ten trains per hour. **W. Langdon** in reply claimed that his tractive resistance formula was true, at any rate for passenger trains, and that his figure of 3·0 lbs. of coal per kw.-hour was higher than has been obtained on the Chicago and Boston Railways. Polyphase systems seem unsuitable on account of the two contact rails necessary and of the speed-rigidity. E. H. C.-H.

990. *Distribution Systems for Tramways.* (Union Int. Permanente de Tramways: Questionnaire, 1900, pp. 94–109; Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 49–56, and 159–170.)—Report of **Van Vloten** (Brussels) on the replies received from various Tramway Companies to whom a question on the above subject had been put (see *Questionnaire*).

A. *Continuous-Current Distribution.*—(1) Distribution at 550–600 volts, with feeders and return mains; single generating station. This system, so suitable for urban lines, is not to be recommended for lines extending beyond 10 kilometres from the station. Its advantages are: Low cost of generation, regularity of service, use of continuous-current motors, and absence of danger to life. Its disadvantages are: High cost of distribution for long lines, loss of energy in distribution, and dangers of electrolysis. These defects can be diminished by the use of batteries placed on the line. (2) Same distribution with several generating stations. The advantages of several stations are, compared with the previous case: Reduction in the cost of distribution, and less danger of electrolysis; while the disadvantage lies in the increased cost of generation. This system is not advisable except where waterfalls are available along the route. (3) Same distribution, with boosters. The use of boosters reduces the cost of distribution, and enables distances up to 16 kilometers to be worked with continuous currents. (4) Three-wire distributions, with rails serving as middle wire. This system is very little employed on account of the difficulty of obtaining balance between the two sides. (5) High-tension distribution, with substations reducing to 550–600 volts. This system presents no advantages over polyphase distribution, except in the case of the Thury series distribution, in which a number of generators are connected in series, as are also the converters, on a line at constant current. This system effects considerable economy in copper, and enables distant waterfalls to be utilised, but has many practical disadvantages. (6) Accumulator traction. This is applicable only to level lines with small traffic. Its advantages are: Low first cost, economy in power at the generating station, absence of electrolysis and danger. Its disadvantages are: Waste of power in carrying the accumulators, increased wear of rails, and high cost of energy at the motor terminals, and of battery maintenance. (7) Mixed system. Trolley and Accumulators. This system is applicable to lines extending a greater distance from the generating station than the 15–20 kilometres admissible with accumulators alone. The batteries being charged in the cars cannot be properly attended to, and are consequently subject to more rapid deterioration.

B. *Distribution by Three-phase Current.*—The author first compares the behaviour of three-phase with continuous-current motors. The former run always at constant speed, and therefore a larger motor is required to give increased power on gradients. The three-phase motor is consequently best adapted to very level lines, as found on main railroads. It has the disadvantage of a very small air-gap, about 1·5 mm., which entails careful supervision of the bearings, while its advantages are: Absence of commutator, simplicity of construction, possibility of supply at high pressure, up to 4,000 volts, and economy in braking the cars, by allowing the motor to give back current to the mains. (1) Systems of direct supply from the trolley wire. The chief advantage of three-phase currents is the use of high pressures, and under this condition the advantages of the system are: Economy in distribution network and working, absence of electrolysis, possibility of using a distant waterfall, or of supplying a long line from one generating station. The disadvantages are: Serious complication in the overhead network due to two trolley wires, necessity of good pressure regulation, unequal loading of the three phases due to the self-induction of the rails, inductive effect on telephone and telegraph circuits, and danger to life. (2) System with transformer substations. This system permits the use of a higher pressure on the supply mains, and a lower pressure on the trolley wires, thus economising in distribution and lessening the difficulty and danger of the trolley construction.

C. *Mixed Systems of Continuous and Three-phase Currents.*—These have the advantages of retaining continuous-current motors and of a single trolley wire, while inductive effects are diminished and batteries can be employed. On the other hand, the rotary transformer substations increase the first cost and the running cost, and lessen the efficiency of the system. The author gives a table of the efficiencies of the various types of generators and transformers, and from it calculates the efficiency of the mixed system when the supply is effected in different ways. He also reproduces Huber's table of the comparative costs of different systems. G. H. B.

991. *Narrow and Standard Gauges for Tramways.* (Union Int. Permanente de Tramways: Questionnaire, 1900, pp. 26–30; Comptes Rendus (International Tramway Congress at Paris), 1900, pp. 37–44 and 143–149.)—The replies received from eleven tramway companies (and given in the *Questionnaire*) form the basis of a report by **Gunderloch** (manager of the "Bergische Kleinbahnen" at Elberfeld), of which the following is an abstract.

The cases in which a gauge of less than 1 metre is employed being very rare, the author confines himself to a comparison of the metre and the standard gauge. (1) The narrow gauge facilitates running on curves of small radius, and gives greater latitude in adapting the track to inequalities of the land. Statistics from sixty-one roads do not, however, show that the narrow gauge has been generally adopted on lines with sharp curves, and the author does not think that the advantage possessed by the narrow gauge in this respect is of itself sufficient to warrant its adoption. The author mentions several methods of permitting a more easy running round curves without resorting to the narrow gauge. (2) The first cost of the narrow gauge track is less than that of the standard gauge; this is more especially the case with lines on virgin ground, and when the track consists of Vignoles rails with metallic sleepers.

In the case of lines laid on existing roads and with girder rails the economy of the narrow gauge is negligible. (3) Lines in communication with standard gauge railways should adopt this gauge in order to admit of the passage of the same rolling stock on both lines; the author enumerates the conditions requisite for this. (4) Narrow gauge does not permit the use of such large motors as does standard gauge. For ordinary services a single motor is admissible on the standard gauge, and this effects an economy in the cost and maintenance of motors and controllers. On the other hand, two motors offer so many advantages that they are usually employed apart from considerations of the gauge. For heavy services, however, where two motors of sufficient power could not be fixed on narrow gauge trucks, the standard gauge has a decided advantage. The narrow gauge again does not permit the use of slow-speed motors mounted on the axle. (5) The arrangement of the motors and other mechanism on narrow gauge trucks is so confined as to render proper access difficult. The motors, too, are more exposed to water splashes from the wheels. (6) Compressed air brakes cannot be fixed on narrow gauge trucks. (7) Standard gauge cars are more stable and their construction is more simple than narrow gauge cars. (8) Collisions with other traffic are more frequent on narrow gauge lines, because drivers of vehicles do not realise how far the cars overhang, and do not therefore keep a sufficient distance off from the track. In conclusion, the author very strongly recommends the universal adoption of standard gauge track.

Discussion.—**De Burlet** (Manager of the Société Nationale Belge des Chemins de fer vicinaux), while agreeing with the report, as far as urban and passenger lines are concerned, considered that the lower first cost of the narrow gauge recommended it for country and goods lines. Such lines, by reason of their small traffic, are commercially possible only if their first cost be kept low. In Belgium, of 108 lines, with a total length of track of 2,500 kilometres, only 3, of a length of 23 kilometres, are of standard gauge. The mean cost per kilometre of the narrow gauge lines is 47,500 francs, while that of the standard gauge is 100,000 francs. The speaker considered that the narrow gauge should always be used, except for a short line, or a line in communication with a main line railroad. **Kessels** mentioned the narrow gauge line at Biella, which is in communication with the main railroad, and stated that the cost of loading and unloading was very small. **Haselmann** (Aix-la-Chapelle) considered that the standard gauge was of advantage only when there was communication with a main railroad, and in certain other special cases. **Trantweiler** (Strassburg) agreed with the report, and thought that the economy of the narrow gauge had been exaggerated; on flat ground, the economy is very small. High-speed, one advantage of electric traction, requires a broad gauge for stability. As regards the transport of goods from a narrow to a broad gauge line, he considered the cost to lie not so much in the handling as in the interest on the value of the rolling stock, which is kept idle during the process. G. H. B.

992. *Electric Traction on the Wansee Railway.* **Bork.** (Elektrotechn. Zeitschr. 22. pp. 70–71, Jan. 17, 1901. Translation in Elect. Engin. Feb. 8, 1901.)—The Railway Department of the German Government is carrying out some experiments on the Wansee Railway in the neighbourhood of Berlin [see Abstract No. 720 (1901)] with a view to collecting facts as to the working of electric traction on railways. The line is a short one, and at present only alternate trains are worked electrically. A maximum speed of 50 km. per hour is reached between stations; the motors are placed direct on the axles of the front and back carriages, there being nine in all on each carriage. The maximum voltage is 750, and batteries are provided at each end of the line to equalise the load. The line is worked on the third-rail principle, the insulated conductor consisting of ordinary rails, supported on insulators at distances of about 4 metres apart, raised about 32 cm. above the track, and at a distance of 1·5 metres from the centre of the same. It is believed that the cost of electric traction is about 16 per cent. less than that of steam traction ; but more exact figures may be shortly expected. The energy used amounts to about 28 watt-hours per ton-kilometre, which is one-third of that consumed in street tramways, this saving being put down mainly to diminished friction on clean rails. W. H. S.

993. *Berlin Electromobile Trials.* (Automotor Journal, 5. pp. 166–167, Jan., 1901.)—Fourteen electric vehicles were tested by Kallmann in April (23–28) last year, and, although the makers' names are not given, the results are here set forth in tabular form. The main points considered were construction, performance, control, prime cost, and maintenance cost. The weights, unloaded, but including battery, vary from 980 to 4,130 kg. The maximum proportion of useful to total weight was found to be 25 per cent. in private cars and 30 per cent. in the vans. The percentage of battery weight to total weight varied from 19 per cent. to 37 per cent. The battery weight per kilowatt hour varied from 55 kg. to 130 kg. Kallmann considers that the battery weight may be taken at 30 per cent. of that of the unloaded vehicle, where 80 km. is run on one charge, but that this figure could be reduced to 25 per cent. with better accumulators. Battery weight to useful load showed a ratio of 0·5 in the best van case, and varied to 1·5 with the van class, and to 3·0 with the private vehicle class. Concerning power, the author considers, from the figures given, that 1 kilowatt per ton of total weight is the average power required for speeds of from 8 to 20 km. per hour. A. G. N.

994. *Charging Station for Electric Automobiles.* **R. A. Fliess.** (Elect. World and Engineer, 37. pp. 5–10, Jan. 5, and 77–81, Jan. 12, 1901.)—These two articles contain a lengthy description of the new premises of the Electric Vehicle Transportation Company of New York. They are designed to accommodate 1,000 44-cell batteries and 500 vehicles, and are at present equipped with 300 vehicles and 500 to 600 batteries. Three-phase current is supplied to the station at 6,300 volts, and is transformed down by four 200-kw. 8-pole rotary converters. The current is delivered to the battery charging switchboards at six different voltages by means of auxiliary storage cells which are inserted in the low tension circuits from the converters, partly as boosters and partly as crushers. The charging of the batteries is entirely regulated by the ammeter, no voltmeters being provided, and as the current through them diminishes they are from time to time shifted on to circuits of higher potential. The station is equipped with an elaborate system of electric cranes for lifting the batteries off their stands, electric transfer trains for conveying them to the vehicles, and hydraulic rams and loading stands actuated by electrically driven pumps for putting them into the vehicles. Full particulars of these are given, as well as of the details of the battery stands, switchboards, and wiring arrangements, and there are a number of illustrations taken from photographs. E. J. W.

995. *Telpherage.* **G. Dary.** (Électricien, 21. pp. 17–21, Jan. 12, 1901.)—After briefly sketching the history of telpherage, the author describes the systems of aërial and underground telpherage of the Consolidated Telpherage Company. In the former system each waggon is equipped with a separate motor, running, by means of a grooved wheel, upon a carrier cable, which forms the return, and collecting current from an overhead trolley wire. A second wheel serves as a guide, and the motor is maintained in a stable condition by the weight of a skip or truck suspended below the cable, or by that of a block and tackle used for handling the skip. The motor is double or quadruple, and is necessarily waterproof. The speed is about 10 or 12 miles per hour, and the weight carried up to 800 kg. The speed is automatically controlled, as well as the stoppage at a terminus. To carry a load of 65 kg. at 12 miles per hour requires $\frac{1}{3}$ h.p.; at starting $\frac{2}{3}$ h.p. is necessary, and $\frac{1}{2}$ h.p. on curves. The whole weight of a quadruple-motor telpher is 90 kg. The line is carried on wooden trestles 50 m. apart, and can be very quickly and cheaply erected.

The underground system consists of tubes of 0·8 or 0·9 m. diameter, fitted with steel rails, upon which run little trains. Energy is supplied to the motors by a trolley line on an automatic block system. A. H. A.

996. *Automatic Block Signals.* (Railroad Gazette, 33. pp. 41–43, Jan. 18, 1901.)—The manual block system has been in use on the line between Pittsburgh, Fort Wayne, and Chicago, but automatic signals worked by electric motors are now employed. There is but one signal for each track at the entrance of each block section, yet the distant signal indication is provided for. But it differs from other systems in having a three-position semaphore by W. M. Grafton. The signal at the entrance of a section which is occupied by a train stands horizontal as usual; but the signal at the entrance of the next section in the rear, which ordinarily would have two arms, one indicating "all clear" for that section and the other "caution" for the succeeding or occupied section, stands in the diagonal position. If the signal is vertical or "all-clear," this indicates that two sections in advance are clear. Each arm has therefore three positions. It is controlled by the track section immediately in front of it by means of the track circuit in the usual manner for "stop," but for "caution," the control is effected by means of a wire on poles from the section where the train is running. A dynamo furnishes current for all the signals, and there is a storage battery at each signal bridge. The electric motors working the signals are $\frac{1}{12}$ h.p. These operate a vertical rod by means of a toothed gear, the rod actuating the semaphore arm. The rod has a series of teeth engaged by a pinion. In order to permit this rod to move down, after the signal has gone to "stop," without reversal of the motor and its train of gearing some of the teeth on the pinion are removed. When the signal is shifted from "stop" to "caution," the motor is automatically cut out by contacts on the post being separated, and when the train has cleared the next section these contacts are restored electromagnetically, the motor is free to work and the arm comes down to "clear." The description of the mechanism and the various circuits cannot well be condensed. E. O. W.

997. *Webb and Thompson Electric Switch and Signal Apparatus.* (Railroad Gazette, 33. pp. 24–25, Jan. 11, 1901.)—This article describes and illustrates a signal cabin at Crewe fitted with this apparatus. The physical exertion necessary with the manual system is obviated, more attention can be given to train movements, points, and signals, and fewer men are required in the cabin. The levers are in two tiers, the upper being used for switch, and the lower for signal movements. The levers are in the upper part of the cabin, the interlocking, electric switches, &c., in the lower, where adjustments or repairs can be made without interfering with the work of the signalman. Carbon contacts are used in the electric switches, and have shown little wear although in use over twelve months. In operating a switch lever, a check lock is brought into play, and the complete movement is restrained until the points are properly over and the rails bolted, when a current is returned to the magnet of the check lock, a pawl is withdrawn, and the lever can be pulled to its limit. Cables laid in rough wood trunking and filled in with pitch convey current to motors contained in cast-iron boxes at the points. The covers of the boxes are level with the upper face of the sleepers and ballast. The movement of the motor is transmitted to the switch movement cam-wheel by means of a worm and worm-wheel, clutches being employed to disengage the motor as soon as the switch movement is completed. The motor itself runs free until the current is cut off. Signal-posts and ground disk signals are operated by the magnet movement as adopted in the Timmis automatic electric signalling on the Liverpool Overhead Railway. E. O. W.

ELECTRIC LAMPS AND LIGHTING.

998. *Electric Train-Lighting.* **E. L. Clark.** (West. Electn. 27. pp. 395–396, Dec. 22, 1900.)—After discussing the ruling conditions, the author describes a system which he has devised, comprising a voltage regulator, field-reversing switch, and automatic battery switch. The regulator consists of a centrifugal governor combined with a rheostat in circuit with the field magnet winding of the dynamo. The latter is self-exciting, and therefore an automatic switch is added to reverse the connections of the shunt coils when the direction of rotation of the armature is changed. The armature has two windings, one for charging the battery, the other for feeding the lamps direct; these are controlled by an automatic device consisting of several switches operated by electromagnets. A. H. A.

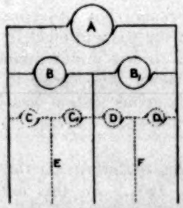
999. *Electric Train-Lighting.* **M. Büttner.** (Elektrotechn. Zeitschr. 22. pp. 17–24; Discussion, pp. 24–29, Jan. 3, 1901. Paper read before the Elektrotechn. Verein, Nov. 27, 1900.)—In this paper, the whole question of lighting railway carriages is discussed. The system of lighting with oil gas in use on the Prussian State Railways is first briefly described, *i.e.*, storing the oil gas in reservoirs under the railway vehicles at a pressure of 6 atmospheres, and connecting the interior of these reservoirs to the burners in the carriages through reducing valves which reduce the pressure to from 25 to 45 mm. of water. Recently 25 to 30 per cent. of acetylene has been added to the oil gas, thus increasing the candle-power (in Hefner candles) of the flames from 5 to about 15. The systems of electric lighting in which dynamos, driven from the axles, work in conjunction with accumulators, are first described. After referring to early experiments, the system of J. Stone & Co., of Deptford, is referred to. In this system, the dynamo is driven by belting from one of the axles, and is switched into and out of circuit with the accumulators and lamps by a centrifugal governor, the belt being arranged so as to slip when a certain speed is exceeded. In Auvert's system, which is used by the *Paris-Lyon Méditerranée Railway Company* the battery supplies current to the lamps and to the field-magnet circuit of the dynamo, the armature of which is automatically switched into circuit when the desired pressure is reached. When the pressure exceeds a predetermined value, a small series motor, having its armature braked, is automatically switched

into circuit, and keeps the pressure at the lamp-terminals constant. In the Moskowitz system, which is used in America, the dynamo field is differentially wound so as to maintain the pressure at the terminals constant at varying speeds. An automatic switch is provided for cutting the dynamo out of and into circuit. The Vicarino system is also referred to. It differs from the Moskowitz system only in the means employed to reverse the poles of the dynamo when the direction of motion of the train is reversed. The Dick system comprises sets of accumulators in each carriage which are charged from a dynamo in one of the vehicles. Methods in which a separate engine and boiler are provided to drive a dynamo in the train are referred to. In one of these, viz., that in use on the Siberian Railway, a De Laval turbine is employed. The author then describes the various systems in which accumulators alone are employed in the trains. In the systems in use on the Danish State Railways, the first and last carriages of a train are each provided with two batteries of 36 cells having a capacity of 120 ampere-hours, the discharging current being 6 amperes, and the charging current 35 amperes. There are two separate circuits in the train, the batteries of one carriage working in parallel on one circuit, and the batteries of the other carriage on the second circuit. The battery boxes are of ebonite, and provided with glass covers. Four of them are mounted together in a wood box, and joined up in series with the end poles connected to contact-bars at the sides. These contact-bars register with contact springs in the separate compartments of a supporting frame, so that the proper connections are made on sliding the boxes into the frame. The arrangements at the charging station are also described. Figures are then given to show that the weight of the installation per carriage is substantially the same as, or even less than, when using oil gas, *e.g.*, using a mixture of oil gas and acetylene, for 5 lights of 15 c.p. burning 27 hours, two gas reservoirs are required, the arrangement weighing 450 to 480 kg. For five 16-c.p. glow-lamps, burning 27 hours, 16 type V-A-55 Hagen cells are employed ; with wood boxes holding 4 cells each and stand, &c., the weight is about 430 kg. The cost of electric lighting is estimated at 0·43 pf. for the Danish State Railways and 0·35 pf. per c.p.-hour (Hefner candle) for the Jura-Simplon Railway. The cost for oil gas amounts to 0·34 pf. per c.p.-hour, and, for a mixture of oil gas and acetylene, to 0·23 pf. The costs of installation per carriage are 700 marks for gas, and 880 marks for electricity. The author advocates, for general purposes, the use of accumulators alone, recharged in the carriages whilst they are idle at the terminus. In the discussion, the electric lighting was rather severely criticised by some of the speakers, one objection given being that assuming the light, cost, and weight of the gas and electric systems to be equal, the gas reservoirs can be re-charged in one minute, whilst the electric accumulators take two hours. Those, however, who spoke in favour of electric lighting, agreed that the most advantageous system was one in which accumulators only were carried in the train, each carriage having its own set. C. K. F.

1000. *Electric Train-Lighting of Railway Carriages.* **E. Dick.** (Elektrotechn. Zeitschr. 22. p. 91, Jan. 24, 1901.)—In this letter a reply is given to M. Büttner and others [see preceding Abstract] who contend that the system in which accumulators alone are used in the carriages is the most advantageous. It is shown that the Dick system, in which a dynamo is carried driven from one of the axles of a carriage (see Schweiz. Bauzeitung, 35, No. 13), is reliable and economical, there being very little wear and tear, and skilled attendance unnecessary. C. K. F.

1001. *Arc-Lamp Standardisation.* **H. Almert.** (West. Electn. 28. p. 88, Feb. 2, 1901. Paper read before the Chicago Elect. Assoc., Jan. 18, 1901.)—The author points out that no practical basis exists for the comparison of the relative values, as light producers, of the different lamps now on the market, and suggests that there should be some definite understanding between manufacturer and user as to what a lamp should and should not do. In arc-light photometry there are many difficulties, the most troublesome of which are the shifting of the arc on the pole-tips, and the difference in colour between the light from the arc and that from the standard. The error due to the first is considerably reduced by the "double-mirror method" of Matthews [see Report of Committee on arc-light photometry of the National Electric Light Association]. It consists simply in taking light simultaneously from opposite sides of the arc by the use of two mirrors suitably adjusted. In addition Matthews uses a rotating sectored disc to reduce to a minimum the error due to colour, but a usual method is to use a series of secondary standards of increasing brightness. In comparing the efficiency of one lamp with another, it must be remembered that it is often the mean intensity of the light in a particular direction, or over a certain portion of a sphere with the lamp as centre, that is to be taken, as the light given out in other directions is wasted, *e.g.*, light given by a street lamp in any direction above the horizontal is for the most part lost. Of the different light standards in use, the author recommends the Reichsanstalt amyl-acetate (or Hefner) lamp as the most satisfactory, though, like the British candle, it is subject to a variation due to atmospheric moisture, amounting, according to Sebenthal, to 8·5 per cent. The paper concludes with an appeal to scientific bodies and institutions to place, within the reach of all, data as to the effect of size and quality of carbons, shades, globes, and globe coatings on the quantity, quality, and distribution of the light produced, and as to the relative efficiencies of the direct and alternating-current arcs, so that it might be possible easily to test the relative merits of different lamps—a feat that the average central-station engineer has no means of performing at present. J. H.

1002. *Arc-Lamps on High-Pressure Supply Systems.* **J. G. Griffin.** (Elect. Rev. 48. pp. 41–42, Jan. 4, 1901.)—An account is given of the difficulties met with in running private arc-lamps on circuits at 200 volts or more. Single enclosed 220-volt lamps were tried at Burnley after changing over from 105 volts, but failed to give satisfaction. Small balancing wires, E F, were then run, in conjunction with two balancers, CC_1, DD_1, at the station, forming a five-wire system as shown in the diagram, and the old 105-volt lamps were replaced on the 110-volt circuits thus provided, with entirely successful results.



The method of measuring the pressure on the arc-lamp circuits, and an automatic device to give warning if an arc lamp is switched on when the balancers are not running, are also described, with diagrams. A. H. A.

REFERENCES.

1003. *Tractive Resistance of Trains.* **L. Barbillion.** (Écl. Électr. 24. pp. 97–102, 1900.)—A review of the various empirical formulæ. H. R. C.

1004. *Power Station at the Kander Falls.* **H. Rupp.** (Elektrotechn. Zeitschr. 21. pp. 898–905, Nov. 1, 1900.)—A full description of the power station, which supplies energy to the Burgdorf-Thun railway, already referred to in Abstract No. 765 (1900). W. H. S.

1005. *Electricity Supply.* **W. A. Chamen.** (Inst. Elect. Engin., Journ. 30. pp. 105–115 ; Discussion, pp. 115–122, Dec., 1900.)—An address before the Glasgow Section, dealing mainly with the Board of Trade regulations as to the pressure of supply.

1006. *Alternating* v. *Continuous Current.* (Inst. Elect. Engin., Journ. 30. pp. 3–26, Dec., 1900.)—A discussion as to the advantages and disadvantages of the two systems.

1007. *Berlin Electric Tramways.* **G. Roessler.** (Elektrotechn. Zeitschr. 21. pp. 932–936, Nov. 8 ; 952–955, Nov. 15 ; 982–984, Nov. 22 ; 1001–1003, Nov. 29 ; and 1019–1023, Dec. 6, 1900. From the Zeitschr. f. Kleinbahnen, Oct., 1900.)—This paper describes in detail the various systems of electric traction in use in Berlin, namely, Surface Contact, Accumulator, and Ordinary Trolley systems. E. K. S.

1008. *Costs of Tramway Construction.* **H. Conradi.** (Tram. Rly. World, 9. pp. 594–598, Dec. 8, 1900.)—This article, which cannot be well abstracted, gives in detail particulars from French tramways of the average costs of—(i) construction of permanent way with various types of rail, (ii) overhead construction on various systems, (iii) underground conduit system, (iv) surface contact system, (v) rolling stock, (vi) steam motors, (vii) compressed air locomotives, (viii) fireless locomotives, (ix) accumulator cars, complete, (x) trolley cars, (xi) conduit cars, as well as the average number of cars required for lines of various characters. E. H. C.-H.

1009. *Electrical Equipment of the South-Eastern and Chatham Railway Company's Locomotive Sheds.* (Electrician, 46. pp. 305–309, Dec. 21, 1900.)—An account is given of the power station erected by the Company at Slade's Green. The article contains some particulars of two electric cranes used in the sheds, which are operated from a cage at the one side below the beam. W. H. S.

1010. *Electric Power and Lighting in a Smelting Works.* **L. Gohs.** (Elektrotechn. Zeitschr. 21. pp. 1038–1046, Dec. 13, 1900.)—A detailed and illustrated account is given of a 1000-kw. installation in South Russia. The system is direct current at 2 × 125 volts, and extensive use is made of motors. W. H. E.

1011. *Series Alternating Current Arc Lamps.* **H. W. Hillman.** (West. Electn. 27. pp. 130–132, 1900. Paper read before the Ohio Electric Light Association at Toledo, Aug. 16, 1900.)—Further details of work carried out on this system. [See Abstract No. 735 (1901).]

1012. *Vienna Tramways.* (Zeitschr. Elektrotechn., Wien, 19. pp. 35–36, Jan. 20, 1901.)—The conditions of the concession by the Austrian Government of the right to convert the Vienna tramways to an electrical system are here given, in so far as these conditions refer to the construction of the line, or to matters of engineering detail.

TELEGRAPHY AND TELEPHONY.

1013. *Type-Printing Telegraphy.* **W. B. Vansize.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 1-23, Jan., 1901.)—The writer describes the apparatus designed by D. Murray for automatic type-printing telegraphy. At the transmitter a special alphabet is employed which is perforated on the transmitter-tape by a keyboard perforator having a separate movable lever for each character. Each character occupies the same linear space on the tape, 0·5 inch, and consists of five subdivisions or elements, either perforations or blanks. There is consequently no need for the use of differential feed mechanism to provide for letters of varying length. The keyboard carries ten punches, one punching magnet, and one spacing magnet, controlling a motor-driven escapement. At the receiving station there is an electromagnetic perforating device which reproduces the transmitting tape spaces and perforations. This tape next passes through an automatic type-writing machine consisting of five longitudinally reciprocating bars, the ends of which engage with five holes in a plate. The tape moves along between the perforated plate and the bars, step by step, one character at a time. When there is coincidence between the bars, the perforations of the tape, and the holes in the plate, contact is made as in the ordinary Wheatstone automatic machine, and by means of a set of notched strips laid across the bars at right angles and a cam-driven electro-motor, the keys of the type-writing machine are depressed, or those of any type-setting or linotype machine can be actuated. The paper includes an account of the mechanism and electrical connections, and also of the method employed for maintaining unison. The best speed attained over 1,050 miles (land lines) was 77 words per minute, counting five letters to a word, assuming a word-space equal to one letter. R. A.

1014. *Sine-wave Transmitter for Cables.* **A. C. Crehore** and **G. O. Squier.** (Elect. World and Engineer, 36. pp. 481-482, Sept. 29, 1900; also Electrician, 45. p. 744, Sept. 7, 1900. Abstract of a paper read before the International Electrical Congress at Paris, Aug. 23, 1900.)—The apparatus was described in Abstract No. 1969 (1900). A trial was made from London to Aberdeen. With the ordinary Wheatstone transmitter the limit of speed on that circuit was 107 words per minute; with the sine-wave transmitter this was increased to 195 words per minute. This increase of speed is partly due to the use of higher voltage. Such high voltages cannot be employed with square-topped sending, owing to sparking at the contacts; but with the sine-wave transmitter the currents are interrupted only at zero instants whatever the e.m.f. Also, sine-wave impulses travel at greater effective velocity through the cable than square-topped impulses of equal frequency. The authors claim that on long cables the speed of signalling can be doubled by sine-wave transmitters. R. A.

1015. *Spark-telegraphy.* **A. Slaby.** (Elektrotechn. Zeitschr. 22. pp. 38-42, Jan. 10, 1901. Report read before the Allgemeine Elektricitäts-Gesellschaft, Dec. 22, 1900; also Electrician, 46. p. 475, Jan. 18, 1901.)—In the case of the earth-wire as used in wireless telegraphy, there is a potential node at the earthed end, and a potential loop at the free end; hence the theoretical length of the resonant wave is four times the length of the air-wire. The practice has been to lead the insulated air-wire to one terminal of the coherer, the other terminal of the coherer being put to earth. The comparatively large capacity of the coherer, however, makes its air-wire terminal a potential node, so that the arrangement responds to some secondary wave. Slaby therefore connects the air-wire directly to earth. To the air-wire he also connects a second wire equal to it, having itself a free end. This second wire may be stretched out in a horizontal direction, or it may be wound on a bobbin. At its free end there is produced a potential loop similar to that at the free end of the air-wire. The practical details have been worked out by Arco, but the description of them is very incomplete. It is claimed that both syntony and selection can be attained by adjustment of the capacity and induction.

R. A.

1016. *Depth of Penetration of Hertzian Waves into the Earth in Wireless Telegraphy.* **E. Lagrange.** (Comptes Rendus, 132. pp. 203–204, Jan. 28, 1901.)—The author describes experiments in which he found that a receiver buried to a depth of 30 cm. is not acted on by waves emitted by a transmitter in its vicinity.

J. E. M.

1017. *Syntonic Wireless Telegraphy.* **R. Blochmann.** (Elektrotechn. Zeitschr. 22. pp. 80–82, Jan. 24, 1901. Report read before the 8th Jahresversammlung des Verbandes Deutscher Elektrotechniker in Kiel, June 19, 1900.)—The author gives a brief history of wireless telegraphy, and then states a theory which he has evolved from consideration of the supposed action of the potential of the vertical wire on the equipotential surfaces due to atmospheric electricity.

J. E.-M.

1018. *Schäfer's "Anti-coherers."* **E. Marx.** (Phys. Zeitschr. 2. pp. 249–253, Jan. 26, 1901.)—These appliances take the place of coherers. They consist of fine linear flaws in a deposit of silver upon glass, and they are made by lightly drawing a fine line with a diamond. Under the impact of electric waves the resistance of the flaw (about 40 ohms for 30 mm.) is increased about threefold, and promptly falls to its original value when the waves cease. The action is so distinct that signals can be received on the open sea at 95 km. distance, which is beyond the range of the coherer. Righi had used slits for the production of sparks by resonance and Neugeschwender for increasing the resistance of the slit upon the impact of electric waves in cases where there is a film of moisture bridging the gap. But in this case the slit is ragged, and there are conducting metallic bridges across the gap and loose particles of silver which fly to and fro when the p.d. across the gap is 3 volts or more: and the presence of moisture is prevented by careful drying of the air in the tube. The current passed is about 30 milliamperes when there are no electric waves. The original value of the resistance is so rapidly restored that signals can be heard in a telephone with extreme sharpness, and with a pair of telephones two persons can listen to independent simultaneous signals of different rhythm, from different inductors. The puppet-dance of particles of silver across the gap causes a sound in the telephone, at about 3 volts p.d., and is visible under a microscope. With a dry gap, breathed upon, electrolysis produces particles of silver which oscillate in the same way; and when the film of moisture disappears, these particles continue to dance and make noise in the telephone. When electric waves impinge on the "anti-coherer," the metallic bridges disappear, temporarily; this accounts for the temporary increase in resistance; but the bridges may not be restored in identical places. At the same time the pitch of the sound heard in the telephone temporarily alters. The appliance may be strengthened and rendered more durable by coating with a solution of collodium in ether. On drying this seems to form cavities in which the loose silver can move; for if shellac in alcohol be used instead, and heated, the whole becomes hide-bound and acts no longer. On exhausting repeatedly under an air-pump the collodion cavities seem to be expanded, and the sensitiveness is increased, up to a limit beyond which the expansion begins to become too great for the number of silver particles present. Silver, somewhat spongy and blue, works best; gold and platinum do not work; with bismuth it is difficult to make a satisfactory slit. The action of the apparatus does not depend upon the length of the slit: and the same results can be obtained by making *one* connecting bridge, say $\frac{1}{10}$ mm. wide, in an indefinitely wide gap, and coating with collodion. The contrivance works much more steadily and less capriciously than the ordinary coherer. A. D.

1019. *Telegraphone Practice.* **E. Ruhmer.** (Phys. Zeitschr. 2. pp. 129–130, 1900.)—The introduction of a polarising cell into the circuit of the recording magnet of the telegraphone considerably increases the sharpness and clearness with which the sound is rendered. This observation is explained by the author as follows: The preliminary magnetisation probably never exceeds 12,000 units, and after the wire leaves the neighbourhood of the electromagnet its magnetic intensity probably falls to about 8,000 units. When the wire is used for recording, its remanent magnetism will then induce pretty high magnetisations in the core of the recording electromagnet, with a maximum of some 8,000 units. Now this value, when looked up on the curve of magnetisation, is seen to correspond to a low permeability, where comparatively large variations of the magneto-motive force only produce small variations of the magnetic flux, and therefore, also small amplitudes of the magnetic waves to be impressed upon the wire. But for loud records it is important that the variations of the magneto-motive force should take place on a steep portion of the magnetisation curve. That condition is fulfilled by introducing a cell in the circuit which shall just compensate the magnetism induced by the wire in the core of the electromagnet. In Poulsen's case the e.m.f. required is only 1 volt. E. E. F.

REFERENCES.

1020. *Cable Speeds.* **F. Breisig.** (Elektrotechn. Zeitschr. 21. pp. 1046–1050, 1900. Communicated by the Kaiserl. Telegraphen-Versuchsamt.)—The author investigates the limits of speed in working through submarine cables, in extension of the method used by W. A. Price (Electrical Review, vol. 41. p. 190, 1897), with special reference to the effect produced on the speed by the condensers and other apparatus at the sending and receiving stations. R. A.

1021. *Telephonic Trasmission.* **W. A. Price.** (Elect. Rev. 48. pp. 9–10, Jan. 4, and 92–95, Jan. 18, 1901.)—A paper occupied with the problem of the possible improvement of the London to Birmingham underground telephone lines by inserting inductive coils or leaks at each of the twenty-two testing-posts which occur at distances of five miles along the line. The theories of O. Heaviside and the work of M. I. Pupin [Abstract No. 2122 (1900)] are applied to the case, and numerical results obtained and discussed. E. H. B.